Iron AND Steel ENGINEER

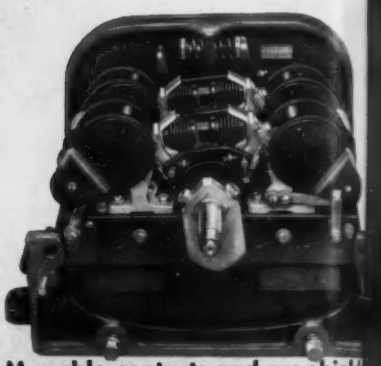
ENGINEERING SERVICE
TO THE IRON AND STEEL
INDUSTRY SINCE 1907

1010 EMPIRE BUILDING | AUGUST, 1942 | PITTSBURGH, PA.

TECHNOLOGY DEPT.
PUBLIC LIBRARY
SEP 1 - 1942

the Crane SAFETY LIMIT STO

-THAT SETS *New Standards of Performance*



Movable contacts and arc shield in position. (Operating hea removed).

C-H Type P-100 100 H.P.

THERE probably has never been a crane safety limit stop switch that so completely embodies *all* the wants of steel mill engineers as the new Type P-100 Cutler-Hammer Safety Limit Stop, for 41 to 100 H.P. installations or the new P-200 Safety Limit Stop for 101 to 200 H.P. installations. This is demonstrated by the fact that time after time engineers have taken one look at it and said: "That is what I want."

C-H Type P-200 200 H.P.

The photographs shown here tell their own story . . . of simple design . . . rugged construction . . . dependable, unfailing operation. Unquestionably, this new Crane Safety Limit Stop sets new standards in every way. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

1892-1942 • 50th ANNIVERSARY

CHECK THESE OUTSTANDING FEATURES

Low headroom required.

Totally enclosed tripping mechanism—can't be made inoperative by rain, snow, ice, dirt or falling objects.

Slate contact supports, slotted, provides ample insulation to ground.

Snap action make and break—hammer blow of tripping is absorbed by spring bumper.

Cover strong enough to support a man's weight.

Rigid one-piece construction of operating lever and tripping weight.

Only one hanging weight, and that has double guides, adjustable to meet any practical installation condition, to prevent fouling the weight by the hoisting cables.

The snap action is obtained from a compression spring, with a very low unit stress. Even if it should break, the mechanism will operate because spring is held in place by an inside guide.

Ball bearings, with means for lubricating by standard grease fittings, used throughout.

Flexible leads brought out for ease of installation.

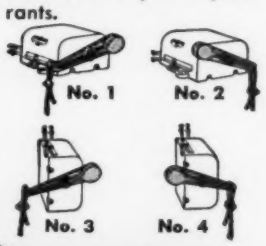
Gasketed cover to keep out dirt.

Mounting interchangeable with old style P-2.

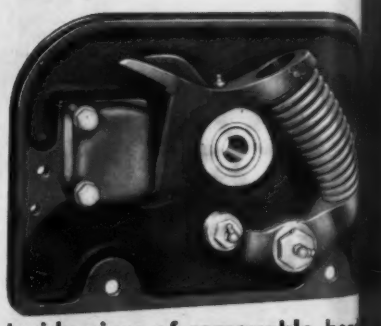
Blowouts latched in place when mounted in position (3) or (4).

Cover chained to case to prevent dropping to ground during inspection.

Operating lever can be mounted in any of 4 quadrants.



CUTLER-HAMMER
MOTOR CONTROL
C-H



Inside view of removable hea showing snap action mechanis

Combined operating lever a tripping weight.

Reset weight with adjustable hoisting cable guides.

Symbols of Freedom

LIBERTY'S TORCH MAY BE QUENCHED . . . BUT HER SPIRIT, NEVER!

The inspiring figure of Liberty, silently guarding the entrance to New York harbor, is a constant reminder to all Americans of the sacrifices of other Americans in building our democratic way of life.

We know that you, too, will agree that helping to furnish the materiel to defend this Democracy is our most urgent task of today.

Aetna Rolls are made in many different shapes to perform a wide variety of duties.

The AETNA-STANDARD ENGINEERING COMPANY

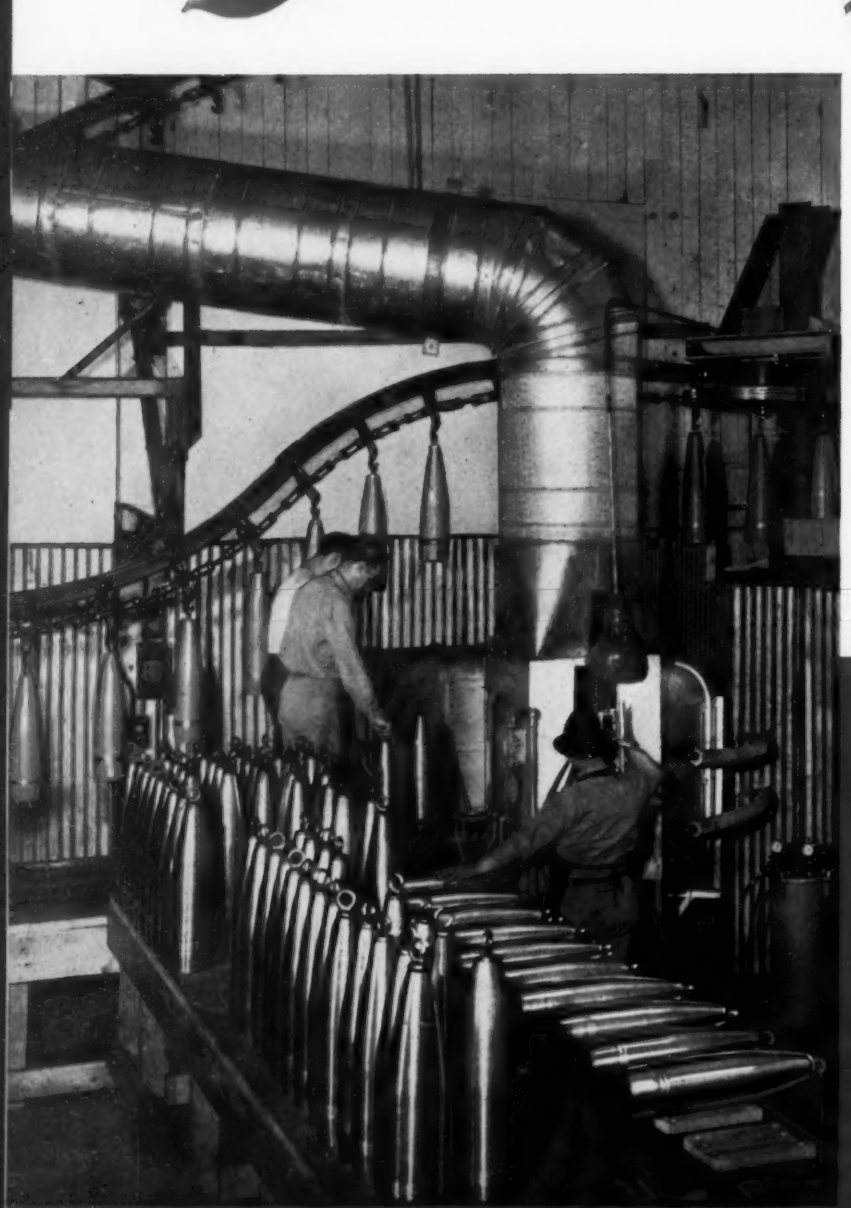
★ YOUNGSTOWN, OHIO, U.S.A. ★

ASSOCIATED COMPANIES

HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND ★
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

Designers and Builders to the Steel, Non-ferrous and Chemical Industries

Wings FOR PRODUCTION LINES



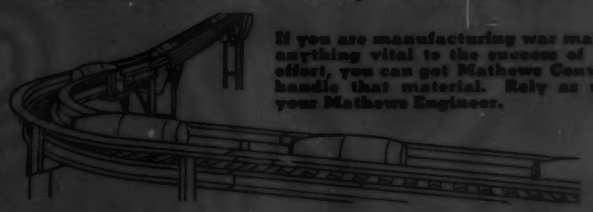
American Industry has one job to do today — get the stuff out better and faster. It just has to be done. There will be no second money paid in this game — either we win or we don't.

Perhaps your production seems to be lagging, and not what you might have hoped it would be. It might be that part of the trouble could be found in your Conveying Equipment or the lack of it.

Your Mathews Engineer would be able to work with you and offer his Engineering experience toward the solution of your problem. You know what has to be done — he might be able to help you do it.

MATHEWS CONVEYER COMPANY

ELLWOOD CITY, PENNSYLVANIA



If you are manufacturing war material, or anything vital to the success of the war effort, you can get Mathews Conveyors to handle that material. Rely as usual on your Mathews Engineer.

MATHEWS CONVEYERS FOR MECHANIZED PRODUCTION

IRON AND STEEL ENGINEER

AUGUST • 1942

VOL. XIX NO. VIII

BRENT WILEY, *Editor*

T. J. ESS, *Associate Editor*

JAMES D. KELLY, *Advertising Manager*

JAMES R. SCOTT, *Production Manager*

Board of Directors

PRESIDENT
THOMAS E. HUGHES
Superintendent of Maintenance
Carnegie-Illinois Steel Corporation
Duquesne, Pennsylvania

1ST VICE-PRESIDENT, FRANK E. FLYNN, *District Manager*, Republic Steel Corporation, Warren, Ohio

2ND VICE-PRESIDENT, C. L. McGRANAHAN, *Assistant General Superintendent*, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

TREASURER, L. F. COFFIN, *Superintendent*, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

SECRETARY, J. L. MILLER, *Assistant Chief Combustion Engineer*, Republic Steel Corporation, Cleveland, Ohio

PAST PRESIDENTS: WILLIAM A. PERRY, *Superintendent Electrical and Power Departments*, Inland Steel Company, Indiana Harbor, Indiana

JULIUS A. CLAUSS, *Chief Engineer*, Great Lakes Steel Corporation, Ecorse, Michigan

HONORARY DIRECTORS: JAMES FARRINGTON, *Electrical Superintendent*, Wheeling Steel Corporation, Steubenville, Ohio

A. C. CUMMINS, *General Superintendent*, Youngstown District, Carnegie-Illinois Steel Corporation, Youngstown, Ohio

WALTER H. BURR, *Electrical Superintendent*, Lukens Steel Company, Coatesville, Pennsylvania

DIRECTOR-AT-LARGE, FREEMAN H. DYKE, *Superintendent*, Blooming, Bar and Hot Strip Mills, Wheeling Steel Corporation, Steubenville, Ohio

DIRECTORS: H. R. MIDDLEBROOK, *Assistant Division Superintendent*, Power and Fuel, Carnegie-Illinois Steel Corporation, Gary, Indiana

A. J. FISHER, *Fuel Engineer*, Bethlehem Steel Company, Sparrows Point, Maryland

H. T. WATTS, *Combustion Engineer*, Republic Steel Corporation, Gadsden, Alabama

T. B. McELRAY, *Superintendent*, Light and Power, Carnegie-Illinois Steel Corporation, Youngstown, Ohio

A. J. F. MacQUEEN, *Superintendent of Maintenance*, Rotary Electric Steel Company, Detroit, Michigan

J. D. JONES, *Chief Engineer*, Youngstown Sheet and Tube Company, Youngstown, Ohio

L. F. REINARTZ, *Works Manager*, American Rolling Mill Company, Middletown, Ohio

A. W. DUNCAN, *Electrical Superintendent*, Weirton Steel Company, Weirton, West Virginia

H. W. NEBLETT, *Development and New Design Engineer*, Inland Steel Company, East Chicago, Indiana

Managing Director
BRENT WILEY
Empire Building, Pittsburgh, Pennsylvania

In This Issue

Recovery and Preparation of Steel Scrap from Steel-Making Furnace Slag and Refuse — By Fred E. Ullman, The Heckett Corporation, Butler, Pennsylvania..... 27

A. I. S. E. Specifications for Electric Overhead Traveling Cranes for Steel Mill Service.....CS-1

Manufacture of Electric Resistance Welded Pipe and Tubing — By J. S. Adelson, Chief Metallurgist, Steel and Tube Division, Republic Steel Corporation, Cleveland, Ohio..... 33

Adjustable Voltage Skip Hoist Control — By F. R. Burt, Metal Working Section, Industry Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania..... 38

A New Hammered Resistance Welding Process — By A. L. Pfeil, President, Universal Power Corporation, Cleveland, Ohio..... 42

Production of Benzol Products by the Continuous Process — By C. R. Lohrey, General Foreman, Great Lakes Steel Corporation, Ecorse, Michigan..... 46

Discussion: Production of Benzol Products by the Continuous Process — Presented by L. R. Milburn, C. R. Lohrey, R. S. Ericson, R. B. Winter, A. R. Borden, and W. H. Collison..... 54

Latest Design and Equipment for the Industry..... 58

Items of Interest..... 66

Index to Advertisers..... 77

Published Monthly by

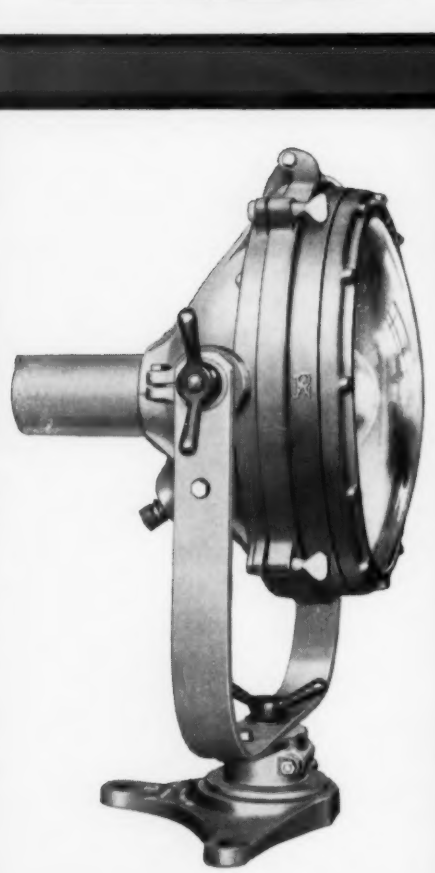
ASSOCIATION OF IRON AND STEEL ENGINEERS

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879

Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expression of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility. Copyright, 1942, The Association of Iron and Steel Engineers

Single Copy Foreign Prepaid $2.00 Single Copy $1.50
Subscription price in U. S. & Canada.....$ 7.50 per year
Subscription price in foreign countries.....$10.00 per year

PLASTIC BINDING U. S. PATENT NO. 1978881 LICENSE NO. 128



DEPENDABLE Lighting Equipment

Built to Withstand Severe Operating Conditions

The substantial protection built into Pyle-National vaportight fixtures and other lighting equipment means dependable lighting even under the most severe operating conditions of steel mill service. Pyle-National heavy duty construction provides weathertight protection for outdoor lighting installations, as well as ability to meet the requirements of shop lighting and other locations where dependable service is of great importance.

The complete line of Pyle-National equipment includes vaportight fixtures in many styles, floodlights, vaportight plugs and receptacles, switches, junction boxes, and circuit breaker Pylets. Fixture hanger Pylets are available in a complete line, for Mercury vapor, reflector, and fluorescent lighting fixtures, including flexible types for pendent fixtures, and hooks and loops for messenger wire suspension. Many of the types available were especially developed to simplify installation and wiring of modern lighting equipment, and to allow for easy maintenance with minimum labor and expense.

Refer to your Pyle-National general catalog 1100 for complete specifications of all types.

PYLE-NATIONAL
ELECTRICAL EQUIPMENT
• SINCE 1897 •

THE PYLE-NATIONAL COMPANY
1334-58 North Kostner Avenue • Chicago, Illinois
Offices: New York · Baltimore · Pittsburgh · St. Louis
St. Paul · San Francisco

CONDUIT FITTINGS • LOCOMOTIVE ELECTRICAL EQUIPMENT • FLOODLIGHT PROJECTORS

This Advertisement first appeared in March, 1939

Mahoning Valley Mill *rebuilds* BLAST FURNACE

Otis Elevator Company builds New Skip Hoist for this Furnace, using EC&M Full Magnetic Rheostatic Control

For the new 1000-ton Blast Furnace recently placed in operation at a prominent Mahoning Valley steel mill, the Otis Elevator Company of New York, N. Y., were selected to build the skip hoist which is operated by an Otis adjustable speed motor and EC&M Full Magnetic Rheostatic Control.

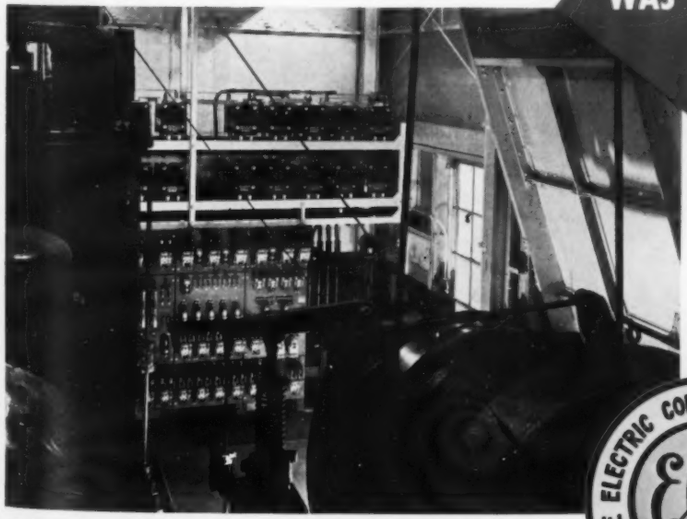
This method of operating the skip hoist was selected because it permits great flexibility and high efficiency on the straight part of the skip-incline and extreme accuracy in stopping combined with low initial cost, low maintenance cost and low power costs.

Of particular interest in connection with this installation was the close co-operation between the Engineering Department of the Otis Company and EC&M Company to incorporate many desirable features in the control which would provide economical, dependable and highly satisfactory operation of the skip under all conditions.

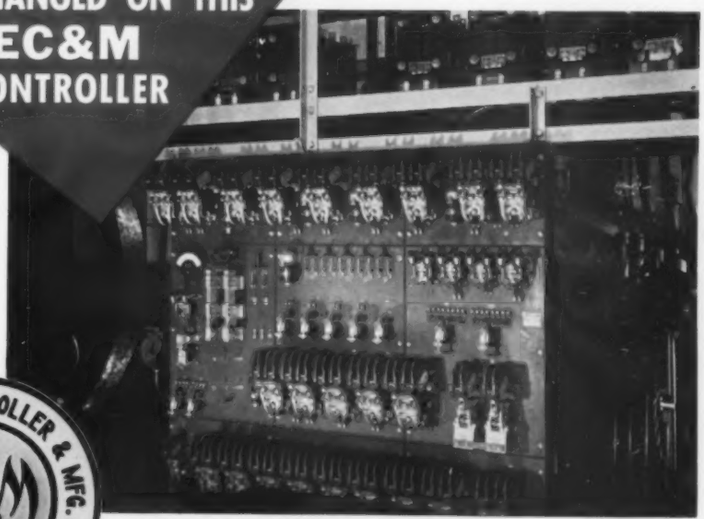
When modernizing blast furnaces or rebuilding existing installations, get the complete details of Full Magnetic Rheostatic Control when planning the electrical equipment for this important step in steel-making. Write the EC&M Company for these facts today.

This installation is but one of a number of the world's largest blast furnaces which have skip hoists operated by an adjustable speed motor and EC&M Full Magnetic Rheostatic Control.

IN OVER 3 YEARS CONTINUOUS OPERATION NOT A SINGLE CONTACT WAS CHANGED ON THIS EC&M CONTROLLER



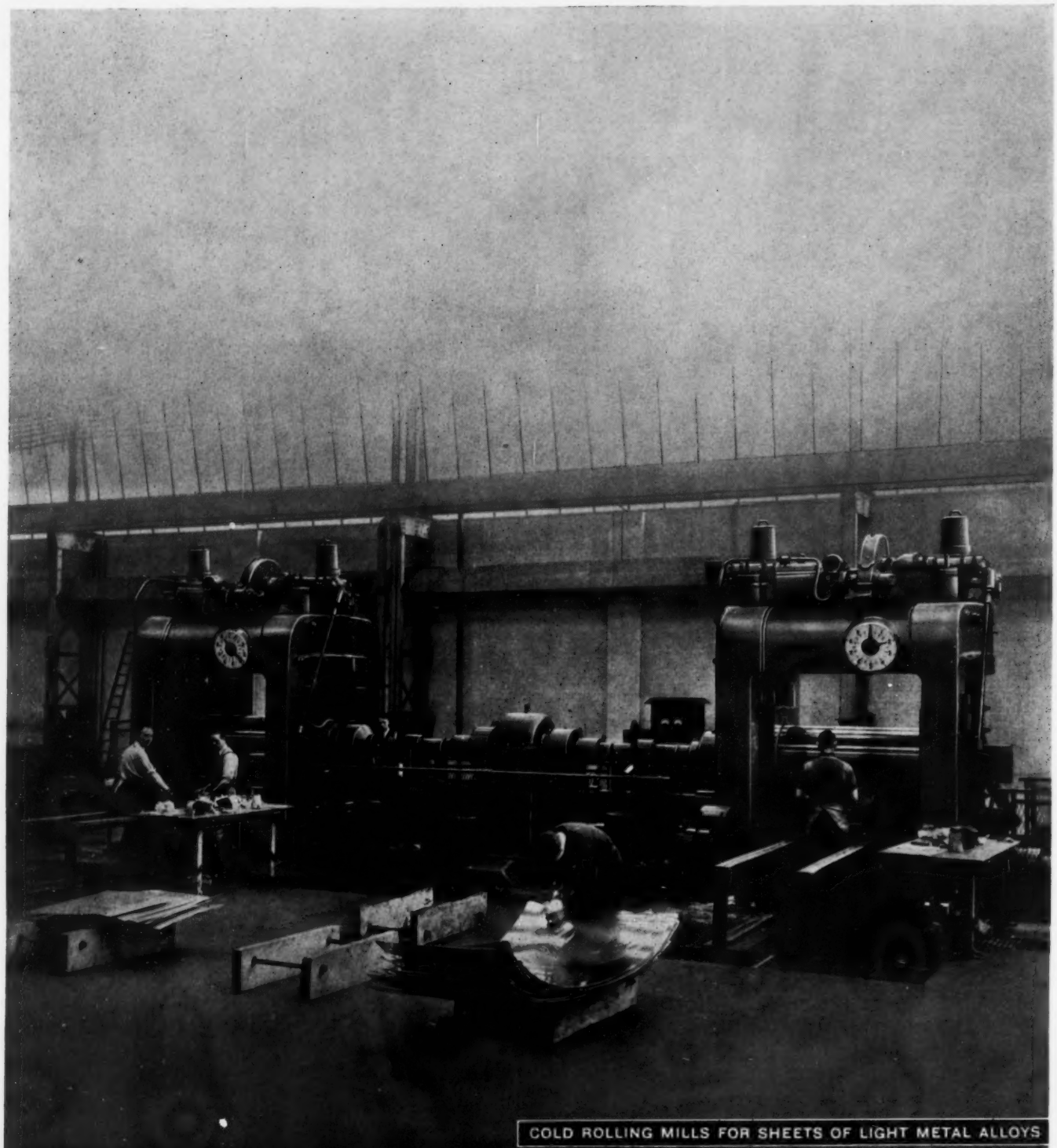
Interior view of the skip-house showing hoisting-cable drum, mechanism for operating large bell and EC&M Control in background.



Close-up view of EC&M Bulletin 925 *LINE-ARC* Magnetic Contactor Controller and EC&M Bulletin 940-C Alloy Grid Resistors.

THE ELECTRIC CONTROLLER & MFG. CO. E&M CLEVELAND, OHIO

EC&M Rheostatic Control for Blast Furnace Skip Hoists



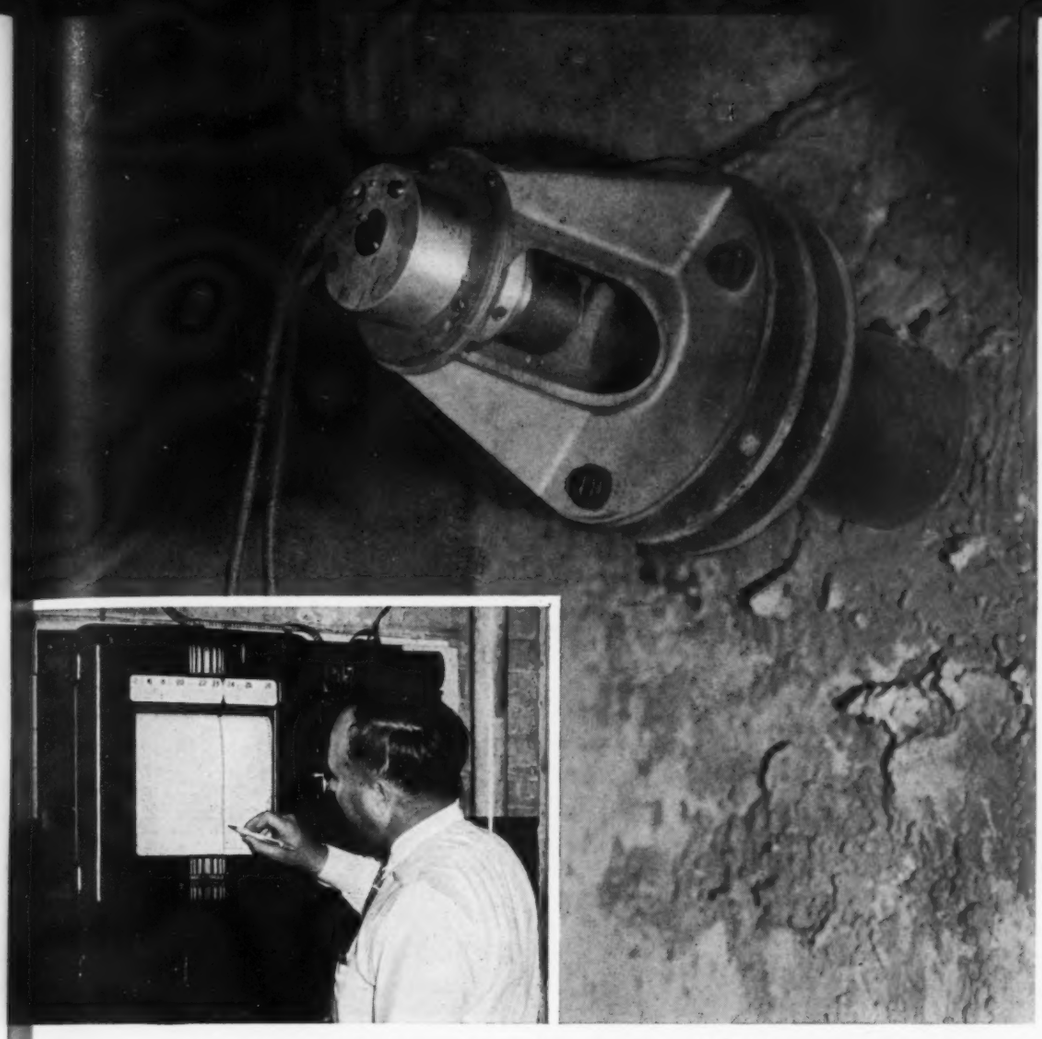
COLD ROLLING MILLS FOR SHEETS OF LIGHT METAL ALLOYS

HYDROPRESS · INC.

ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS
PUMPS · ACCUMULATORS

570 LEXINGTON AVENUE · NEW YORK · N. Y.



Rayotube, installed in furnace, is detecting temperature which Micromax Pyrometer, in insert, records and controls.

THERMOCOUPLES SCARCE?

Maybe Rayotubes Can Serve As Well — Or Better

At the time this is written, the conservation of metals has led to certain official restrictions in the use of the thermocouples, couple-protecting tubes, and leadwires which are accessories to pyrometers, in measuring the temperatures of furnaces, etc.

Before new thermocouples are needed, therefore, some companies may wish to see whether they can use Rayotubes where they have been using couples. We suggest this possibility because a Rayotube lasts for years where a thermocouple may last for weeks or months, with consequent saving of much critical material.

Probably Rayotube's usefulness as an alternate to couples is best shown by those applications for which they are not alternate, but are preferred, and have for years been used by thousands. Such applications include:

(1) Temperatures too high for couples; or so high couples don't last; or so high couples require excessive protection and are sluggish.

(2) Temperatures where furnace gases are too corrosive for couples.

(3) Temperatures of furnaces in which vibration breaks couples.

(4) Temperatures of objects in motion.

(5) Temperature of surface of an object, rather than of a furnace gas, when greater sensitivity of control is desired.

Rayotubes can be used for temperatures as low as 650 F in certain cases. They are completely at home from 900 F, up through and above the couple range, for indicating, recording and automatic control.

If you give us a specific problem, we will gladly tell you whether or not Rayotube can handle it, and recommend Rayotubes, thermocouples, or an Optical Pyrometer, as the case may be.

"Oh! Say Can You See!" is the title of this photograph which won, for Photographer R. W. Knauft, Sales Manager of Chas. Taylor Sons Co., first prize in Industrial Division of Ceramic Camera Club exhibit. It shows D. I. Smith using an L&N Optical Pyrometer in the Taylor refractories plant.

Optical Pyrometer Can Help Users of Other Pyrometers

Whether your plant uses thermocouples or Rayotubes to detect the temperatures which are regulated by its control pyrometers, it's almost certain that an L&N Optical Pyrometer can help in furnace operation. User simply looks through it at the hot work, turns a knob until a "bar" in the eyepiece seems to melt into the work, and reads the temperature in degrees. Readings can show difference between temperatures in different parts of furnace, between couples and work, etc.

Catalog N-33D gives further details; or, for special service, outline your problem and priority situation.

Pair of Rayotubes on a Stewart controlled-atmosphere broach-heating furnace; La-Pointe Mach. Tool Co., Hudson, Mass.

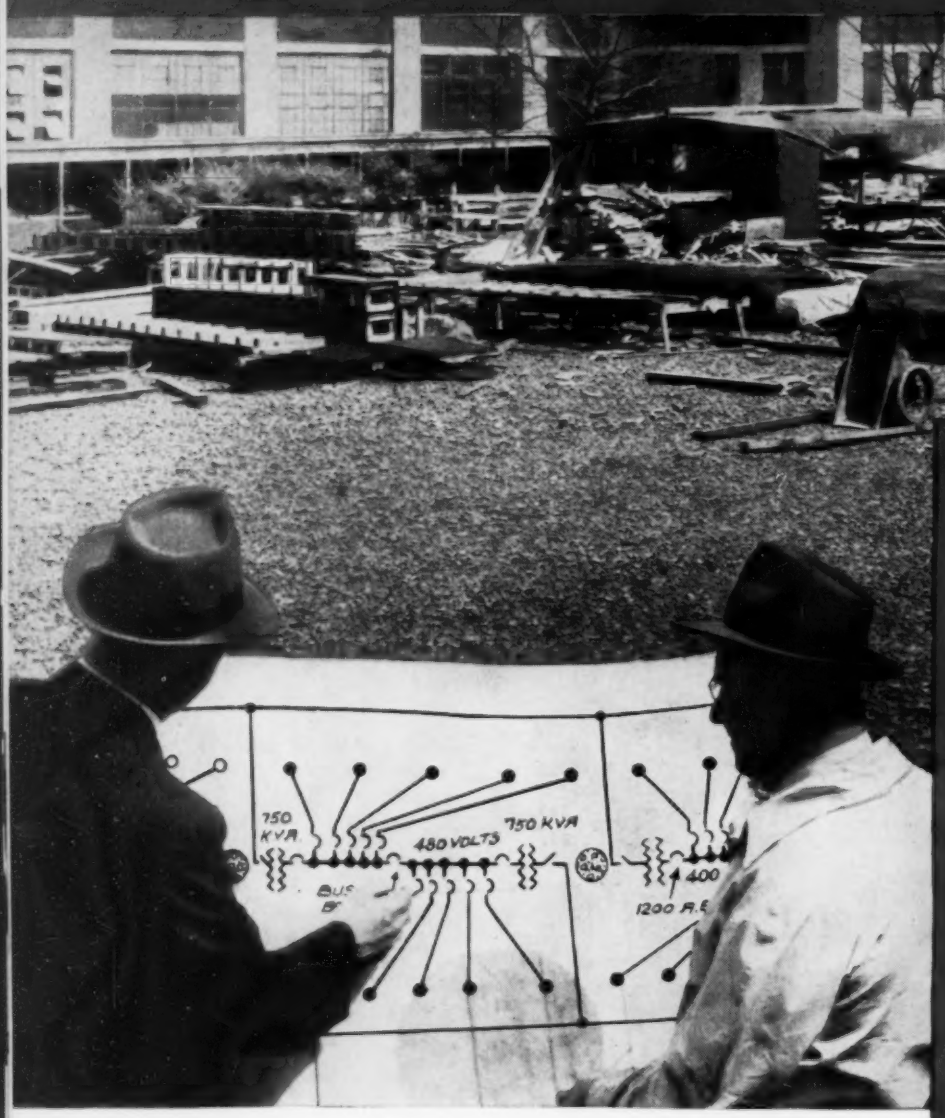
Jrl Ad N-33-600(9)

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

How to PROVIDE PLANT POWER QUICKLY



Take these 3 simple steps and you can order switchgear equipments and unit substations at an early stage of construction—*save weeks of time.*

1. ***Calculate the total kva you need*** Load densities commonly range from 5 to 25 volt-amperes per square foot of floor area. Assembly areas usually fall in the lower range, intensive manufacturing areas in the upper range. Your consulting engineers can help you to predict your load density accurately.

2. ***Divide the load area into separate load zones of 500, 750, or 1000 kva***

3. ***Divide the load of each zone into feeder loads***—and draw a one-line diagram of your proposed load-center system, showing the functions to be performed and the ratings required.

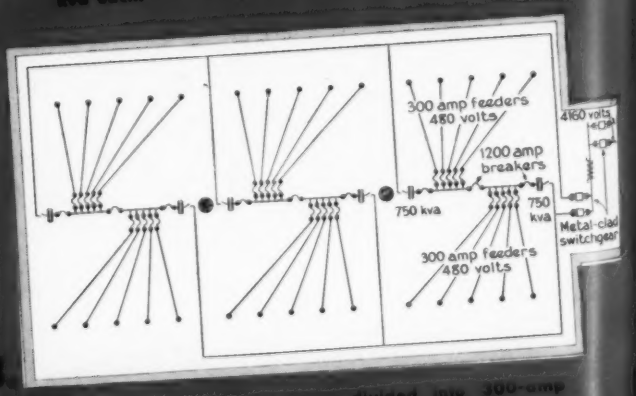
Now, with this one-line diagram, you can immediately order your switchgear and unit substations.

Here's How Equipment Was Ordered for This Industrial War Plant Now under Construction

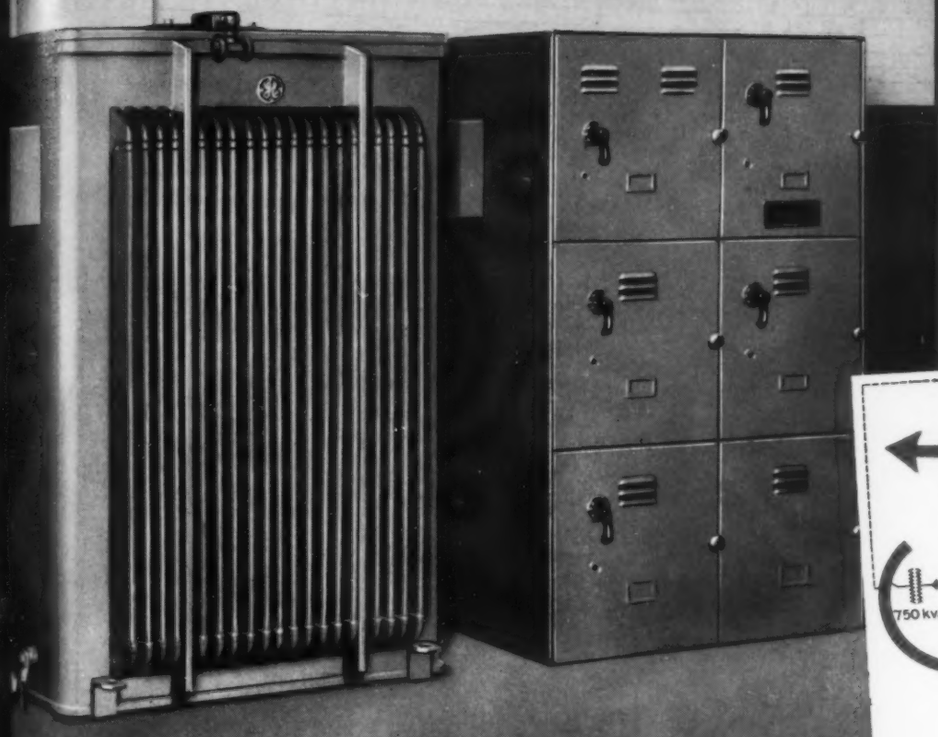
1. Pillar Pillar

400 feet by 750 feet
Load density—15 v-a per square foot
4500 kva at 480 volts

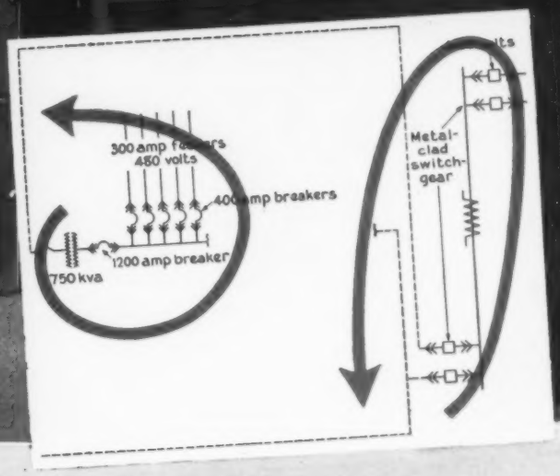
2. The load area was divided into six load zones of 750 kva each.

3. 

The load of each zone was divided into 300-amp feeders, each zone having 1200-amp breakers for main and bus-tie service. Equipments were ordered promptly by means of a one-line diagram.



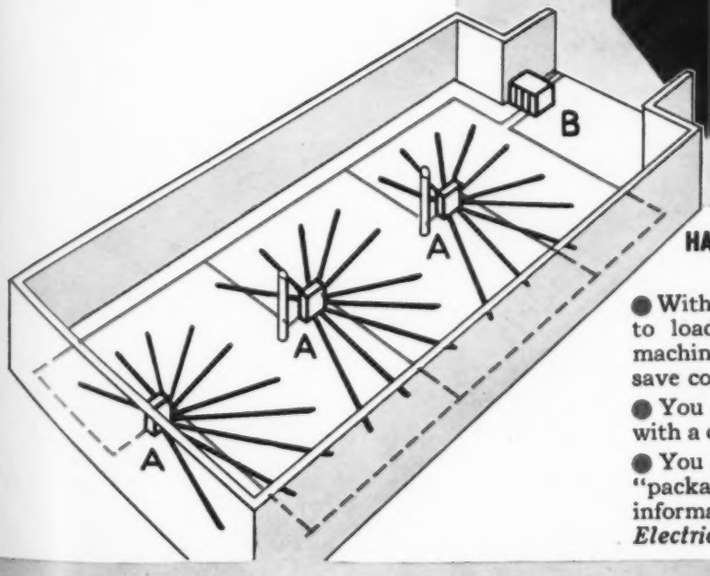
A SIMPLE ONE-LINE DIAGRAM PUTS US TO WORK ON STANDARD EQUIPMENTS



A *Load-center Unit Substations*—including transformer and high- and low-voltage protective and disconnecting devices, all co-ordinated as a single, safe, compact, easy-to-install unit.

B *Metal-clad Switchgear Equipments*—for protecting primary circuits up to 15 kv. A safe, co-ordinated assembly of breakers, instrument transformers, buses, and associated equipment.

General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.



HAVE LOAD-CENTER POWER BEFORE THE FIRST MACHINE IS READY TO ROLL

● With load-center distribution, power at high voltage goes right to load-center unit substations, and then directly to your machines through *short* low-voltage secondary feeders. You save copper, steel and dollars.

● You can order *standard* G-E load-center equipments *early*—with a one-line diagram. Get everything you need—weeks sooner.

● You get them ready to set in place and connect—in compact "packages" that can be put in otherwise "dead" area. For full information, contact your nearest G-E Office, or write *General Electric, Schenectady, N. Y.*

GENERAL ELECTRIC

354-11-1300

KEEP THE CHIPS FLYING

And brother, will they "take off" when the Billeteer starts cleaning up in your Chipping Department!

Don't be a SIXTH* Columnist!

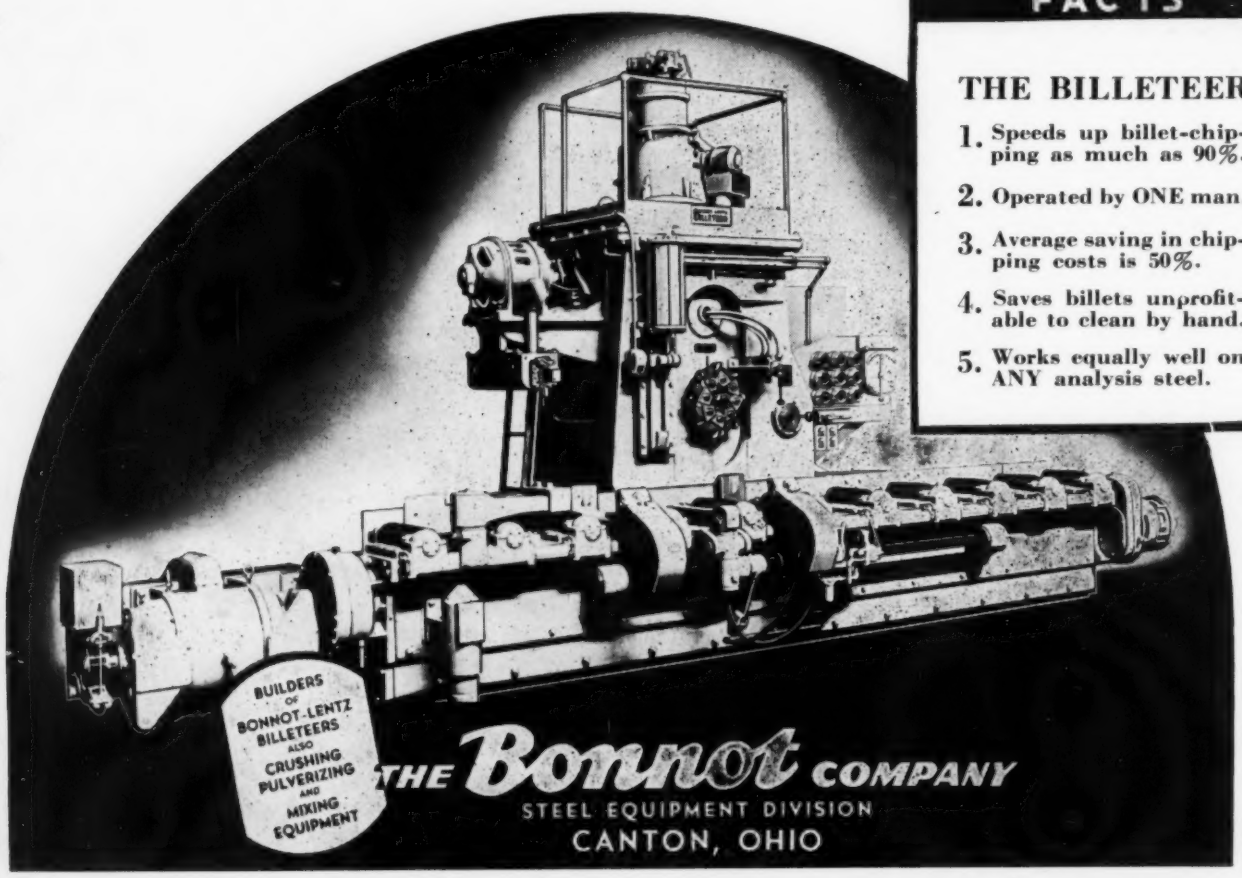
(**One Who Lags Behind in Production*)

The Billeteer is "must" equipment for any modern steel mill. *Must*, because production is needed NOW for something more important than profits. *Must*, after Victory because, then, the dollars saved in billet cleaning will give you an advantage in obtaining orders that will be bitterly competed for.

Your mill won't really be stripped for action until the Billeteer is on the firing line, turning out thoroughly cleaned billets in 1/10 to 1/20 the time required by a skilled hand chipper.

BILLETEERS

carry a very high priority rating — talk with one of our sales engineers and get your order placed as soon as possible.


BUILDERS OF BONNOT-LENTZ BILLETEERS ALSO CRUSHING PULVERIZING AND MIXING EQUIPMENT
THE Bonnot COMPANY
STEEL EQUIPMENT DIVISION
CANTON, OHIO

FACTS

THE BILLETEER

1. **Speeds up billet-chipping as much as 90%.**
2. **Operated by ONE man.**
3. **Average saving in chipping costs is 50%.**
4. **Saves billets unprofitable to clean by hand.**
5. **Works equally well on ANY analysis steel.**

The WEAN

ENGINEERING COMPANY, Inc. • WARREN, OHIO

SPECIALISTS IN SHEET, TIN AND STRIP MILL EQUIPMENT

ARMOR PLATE LEVELLERS

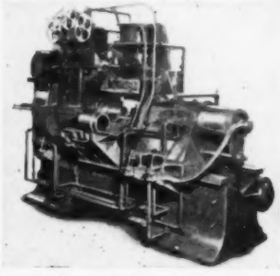
HI-SPEED SHEET AND TIN MILL SHEAR LINES

ELECTROLYTIC & BONDERIZING TIN PLATE EQUIPMENT

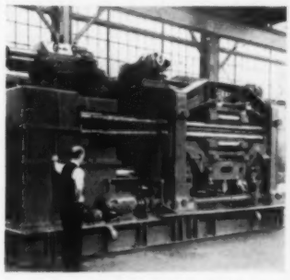
WILSON TUBE ANNEALING FURNACES

WEAN VACUUM CUP SHEET AND PLATE LIFTERS

CONTINUOUS STRIP PICKLING, SLITTING, SIDE TRIMMING, AND RECOILING LINES

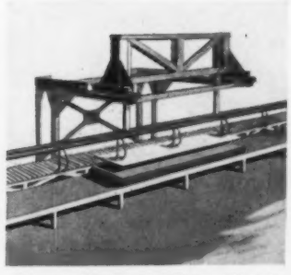


Shell and Sleeve Lathe



Armor Plate Leveller

Wilson Tube Type Annealing Furnace



Wean Vacuum Cup Sheet and Plate Lifter

For Victory!

SUBSIDIARY COMPANY: THE BROWN CONSTRUCTION CO., CLEVELAND, O. — HEART OF STRIP AND PIPE MILL DESIGN

"GETTING SOFT" ...EH?

"BEWARE of an America aroused!"

Sure we've been rolling on rubber—eating our sirloin steaks—lolling in the luxuries which only free Americans have the God-given genius to create, and the capacity to enjoy. But we can still take it, and we can still dish it out.

The world knows now that this "love of luxury" is just a thin outer garment, easily whipped off in an emergency—and that, underneath it, there are muscles of steel.

Sacrifice? We will sacrifice anything but our Liberty!

Suffering? We still remember about Valley Forge, and the blood of our fathers on the snow!

Death? Better death, any day, than life without freedom!

So they said we'd rather lose a war than lose an election? And those cracks, dividing us, were deep craters—not just surface scratches? Management wouldn't work with men, and men wouldn't work with management? And we couldn't get going *fast enough* to become a real factor in this war?

What a jolt the Axis is in for! You might just as well try to sweep the tide back with a broom as try to buck American machines, driven by free, skilled American workers.

◆ ◆ ◆

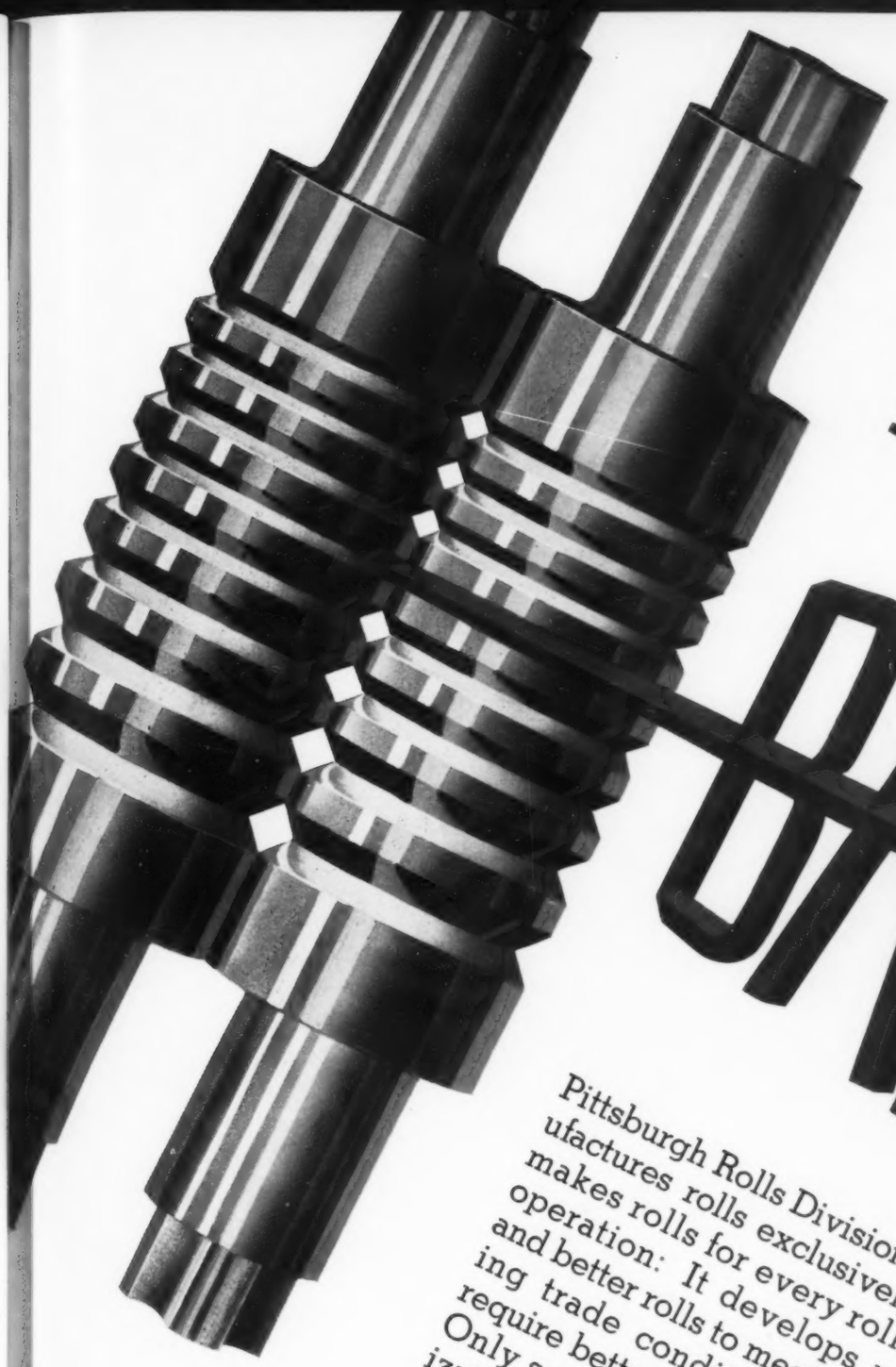
Inspired by the job our own workers are doing, we view this crisis, not with alarm—but with confidence. Every lathe, every drill, every tool in our plants has been turned into a weapon of war—every worker, man or woman, into a PRODUCTIONEER—a soldier in overalls. Such spirit, such skill, such strength cannot lose—for these men and women are fighting *with their hearts,* as well as with their heads and their hands—fighting, along with the millions of other patriotic workers throughout all America—to STAY FREE!

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

LINK-BELT COMPANY—INDIANAPOLIS—PHILADELPHIA—CHICAGO—ATLANTA—DALLAS—SAN FRANCISCO—CEDAR RAPIDS
THE LEAD NG MANUFACTURER OF EQUIPMENT FOR HANDLING MATERIALS AND TRANSMITTING POWER

Reprints in 4 colors furnished on request. Address: 307 N. Michigan Ave. Chicago.

8900A Copyright 1942 by Link-Belt Company



LESS COST PER TON OF STEEL ROLLED

BARS

Pittsburgh Rolls Division manufactures rolls exclusively: It makes rolls for every rolling operation: It develops new and better rolls to meet changing trade conditions which require better rolled products. Only such intensive specialization can give satisfactory up-to-date roll service.

PITTSBURGH ROLLS

PITTSBURGH ROLLS DIVISION of BLAW-KNOX CO.—"Steel's Partner" • PITTSBURGH, PA.

A BAKER MATERIAL HANDLING ENGINEER *can help you to...*

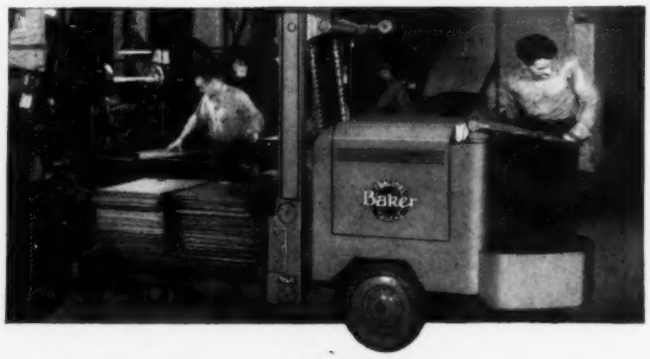
1. Increase Plant Capacity
2. Conserve Man Power
3. Speed Your Deliveries
4. Cut Production Costs
5. Improve Plant Safety
6. Plan Future Material Handling Requirements

All Baker representatives are qualified material handling engineers. They have been in hundreds of plants, and know intimately the problems confronting you wherever materials or finished products are to be moved—in the plant, in the warehouse, on the shipping or receiving platforms, and on shipping piers—they can evaluate your complete handling set-up, and recommend the type of equipment best suited to your plant. If you are after any of the objectives outlined above, it will be well worth your while to seek advice of the Baker representative nearest you.

BAKER INDUSTRIAL TRUCK DIVISION
of The Baker Raulang Company
2166 West 25th St. • • Cleveland, Ohio

Typical Case of Baker Material Handling Engineering Service

Recently a manufacturer, contemplating plant expansion to meet increased production schedules, called in a Baker Engineer to discuss truck requirements. After a complete survey, the Baker Engineer submitted a plan which achieved the production objectives without plant expansion, by a readjustment of material handling facilities and the addition of new equipment, thus avoiding the expense and inconvenience of new construction.

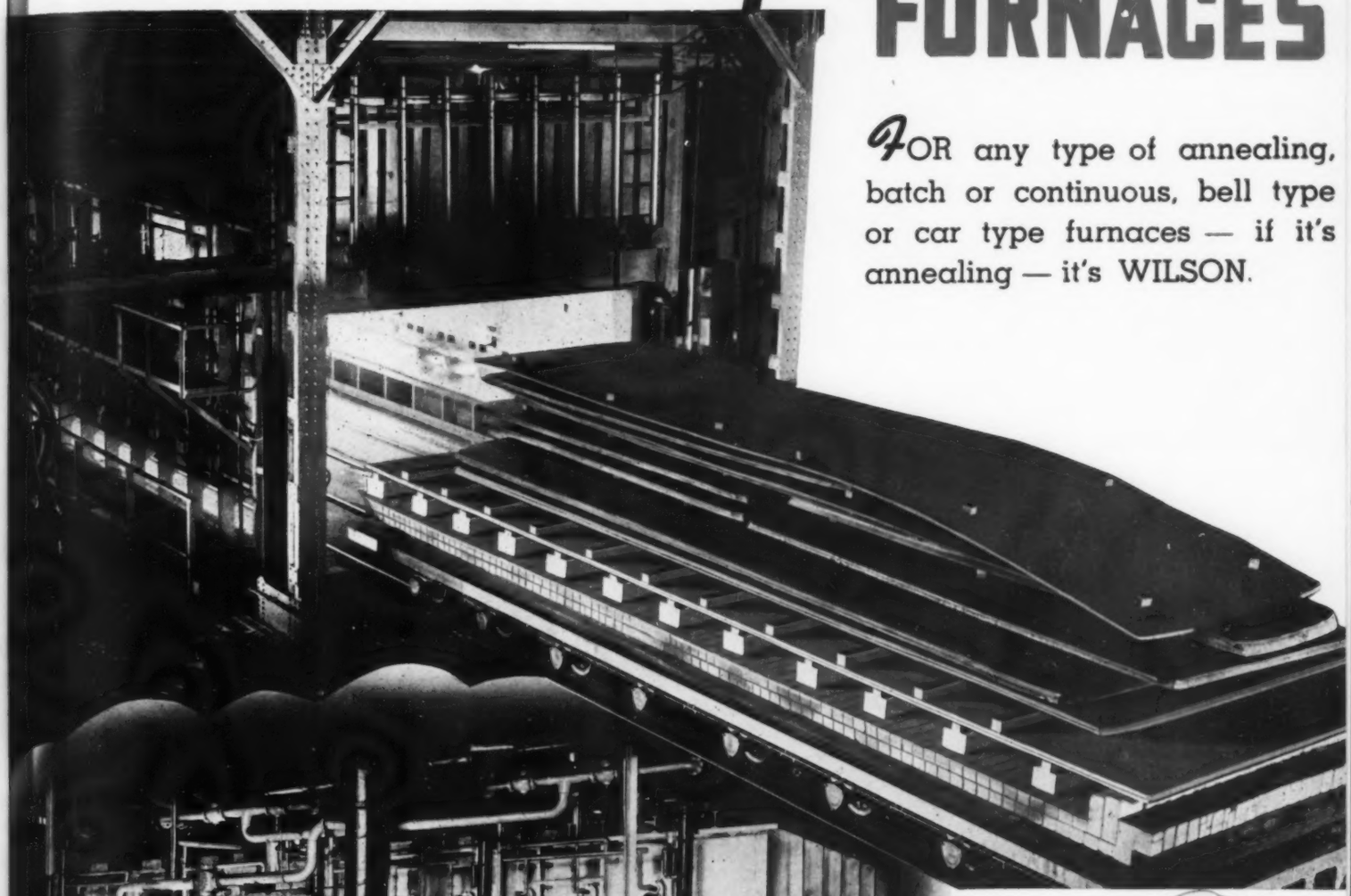


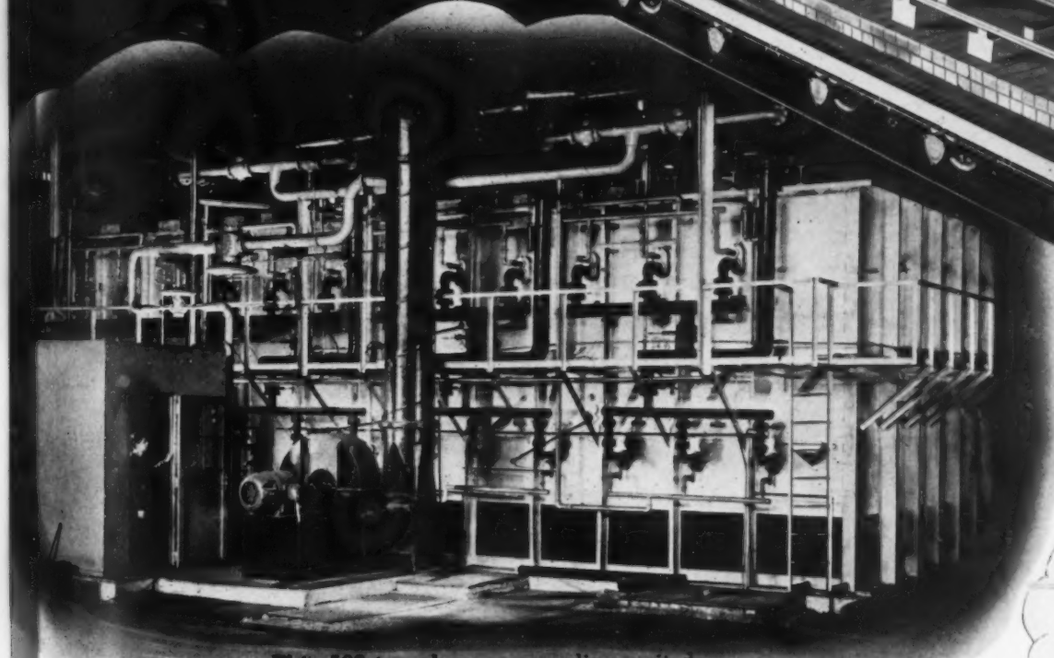
Baker INDUSTRIAL TRUCKS

In Canada: Railway and Power Engineering Corporation, Ltd.

WILSON Annealing FURNACES

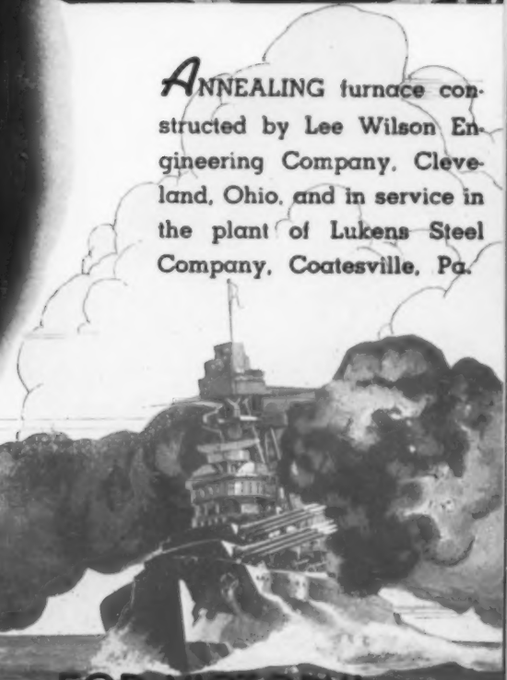
FOR any type of annealing, batch or continuous, bell type or car type furnaces — if it's annealing — it's WILSON.





This 500 ton charge annealing unit designed and engineered by

ANNEALING furnace constructed by Lee Wilson Engineering Company, Cleveland, Ohio, and in service in the plant of Lukens Steel Company, Coatesville, Pa.



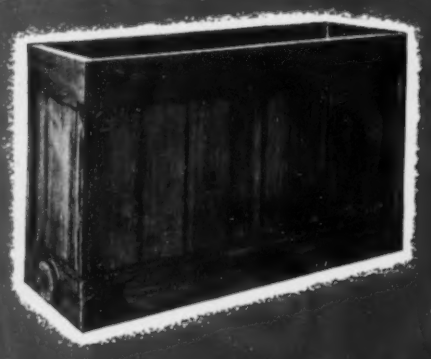
LEE WILSON
ENGINEERING COMPANY
20005 LAKE ROAD • CLEVELAND, OHIO

— FOR VICTORY! —

STOP LOSSES ... FROM CORROSION AND THERMAL SHOCK

IN EQUIPMENT DESIGNED FOR THE PRODUCTION OR USE OF

Hydrochloric Acid



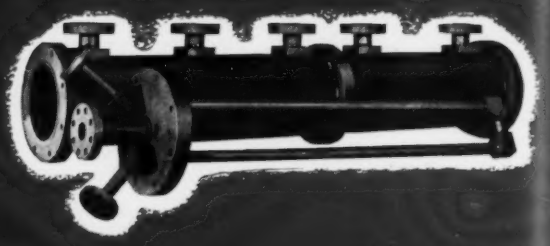
BY USING

National TRADE-MARK

AND **Karbate*** TRADE-MARK

CARBON AND GRAPHITE MATERIALS

FOR THE CONSTRUCTION OF PROCESSING UNITS



* The words "National" and "Karbate" are trade-marks of National Carbon Company, Inc. The trade-mark "Karbate" identifies a line of carbon and graphite base materials impervious to escapage of liquids and gases under pressure.

● Carbon, graphite and "Karbate" materials are used in the construction of equipment for all processes involved in the manufacture or use of hydrochloric acid. This includes absorbing, cooling, rectifying, boiling and condensing units, conveying and circulating systems, vats, tanks and other containers.

These materials are resistant to the action of hydrochloric acid in all phases and concentrations. The excellent heat transfer properties of graphite base materials are of advantage in equipment used for heating, cooling and stripping processes. Good mechanical strength, exceptional resistance to thermal shock, ease of machining, and availability in a wide variety of forms adapt these products to the fabrication of practically any desired type of processing equipment.

EXPERIENCE HAS PROVED THE DURABILITY OF CARBON AND GRAPHITE MATERIALS IN THE PRESENCE OF HYDROCHLORIC ACID AND THE ECONOMY RESULTING FROM THEIR USE

WHATEVER YOUR PROBLEM — *Consider Carbon and Graphite* — WRITE FOR INFORMATION

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

Carbon Sales Division, Cleveland, Ohio

GENERAL OFFICES

30 East 42nd Street, New York, N. Y.

BRANCH SALES OFFICES

New York, Pittsburgh, Chicago, St. Louis, San Francisco

PROGRAM

ANNUAL MEETING & ENGINEERING CONFERENCE

ASSOCIATION OF IRON & STEEL ENGINEERS

WILLIAM PENN HOTEL · PITTSBURGH · PA

SEPTEMBER 22 · 23 · 24

. . . In issuing this invitation to the engineering and operating personnel of the iron and steel industry to attend the annual meeting and engineering conference of the Association of Iron and Steel Engineers, I am giving the opportunity for the free exchange of ideas and information which industry has found so necessary in increasing production to meet the war program. I strongly urge everyone to take advantage of this opportunity to help the war effort by active participation in this meeting.

Thos E Vaughen

PRESIDENT

Tuesday, September 22

9:00 A.M. — REGISTRATION.

Chairman
CHARLES H. WILLIAMS
Assistant to Vice President of Engineering
United States Steel Corporation of Delaware
Pittsburgh, Pennsylvania

Vice-Chairman:
HOWARD F. MARTIN
Maintenance Superintendent
Jones & Laughlin Steel Corporation
Aliquippa, Pennsylvania

9:15 A.M. — BUSINESS SESSION — Cardinal Room.

Chairman:
T. E. HUGHES
Superintendent of Maintenance
Carnegie-Illinois Steel Corporation
Duquesne, Pennsylvania

Vice-Chairman:
J. L. MILLER
Assistant Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

9:30 A.M. — ELECTRICAL ENGINEERING DIVISION — Cardinal Room.

Chairman:
L. V. BLACK
Superintendent of Electrical Department
Bethlehem Steel Company
Bethlehem, Pennsylvania

Vice-Chairman:
J. H. MILLER
Electrical Engineer
Wisconsin Steel Works
Chicago, Illinois

"Air-Break Circuit Breakers for Industrial Use," by Ralph Lockett, Application Engineer, I-T-E Circuit Breaker Company, Philadelphia, Pennsylvania.

"Carbon Brushes — Selection, Application and Maintenance," by Richard Rowell, Assistant Electrical Superintendent, Wheeling Steel Corporation, Steubenville, Ohio.

"Electrical Equipment for Continuous Electrolytic Tinplating of Steel Strip," by J. H. Hopper, Industrial Engineering Department, General Electric Company, Schenectady, New York.

1:30 P.M. — ELECTRICAL ENGINEERING DIVISION — Cardinal Room.

Chairman:
H. R. FORD
Electrical Engineer
Wheeling Steel Corporation
Steubenville, Ohio

Vice-Chairman:
E. L. ANDERSON
Electrical Superintendent
Bethlehem Steel Company
Johnstown, Pennsylvania

"Conservation of Critical Materials in Transformer Design and Application," by J. K. Hodnette, Engineering Manager, Westinghouse Electric and Manufacturing Company, Sharon, Pennsylvania.

"Gauge Control in Cold Rolling of Steel Strip," by J. D. Campbell, Industrial Engineering Department, General Electric Company, Schenectady, New York.

"The Blast Furnace Skip Hoist," by Gordon Fox, Vice President, Freyn Engineering Company, Chicago, Illinois.

"Modern Blast Furnace Charging Equipment," by L. R. Milburn, Electrical Engineer, Great Lakes Steel Corporation, Ecorse, Michigan.

1:30 P.M. — WELDING DIVISION — Forum Room.

Chairman:
M. M. MacDONALD
Electrical Superintendent
Andrews Steel Company
Newport, Kentucky

Vice-Chairman:
WRAY DUDLEY
Assistant Superintendent of Maintenance
National Tube Company
McKeesport, Pennsylvania

"A-C Welding in the Steel Industry," by Emil Steinert, and W. W. Reddie, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

"Welding Metallurgy," by W. G. Theisinger, Director of Welding Research, Lukens Steel Company, Coatesville, Pennsylvania.

"Preparation and Handling for Welding," by A. E. Gibson, President, The Wellman Engineering Company, Cleveland, Ohio.

8:00 P.M. — "VICTORY THROUGH PRODUCTION" — Urban Room.
Motion Pictures, selected subjects.

Wednesday, September 23

9:00 A.M. — OPERATING PRACTICE DIVISION — Cardinal Room.

Chairman:
ALEX MONTGOMERY, JR.
Superintedent of Rolling
Carnegie-Illinois Steel Corporation
Duquesne, Pennsylvania

Vice-Chairman:
ALEX D. BRODIE
Superintendent 93 In. Cold Strip Mill and Galvanizing Department
Jones & Laughlin Steel Corporation
Pittsburgh, Pennsylvania

"Roll Oils and Coolants for the Cold Mill," by Maurice Reswick, Lubrication Engineer, Standard Oil Company of New Jersey, Pittsburgh, Pennsylvania.

"Electrolytic Tinning," by William Cooper, Electrical Engineer, Crown Cork and Seal Company, Baltimore, Maryland.

"Modern Roll Design Practice," by Clifford Elms, Chief Engineer, Pittsburgh Rolls Division, Blaw-Knox Company, Pittsburgh, Pennsylvania.

1:30 P.M. — OPERATING PRACTICE DIVISION — Forum Room.

Chairman:
WM. H. COLLISON
Superintendent of By-Product Coke Plant
Great Lakes Steel Corporation
Ecorse, Detroit, Michigan

Vice-Chairman:
J. D. JONES
Chief Engineer
Youngstown Sheet and Tube Company
Youngstown, Ohio

"Innovations in Coke Oven Design," by M. D. Curran, President, The Coal Carbonizing Company, St. Louis, Missouri.

"Properties of Blast Furnace Cokes: Their Measurements, Significance and Control," by H. H. Lowry and M. A. Mayers, Coal Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pennsylvania

"Coal Washing and Its Effect on Coke Oven and Blast Furnace Practice," by Wm. S. McAleer, McNally Pittsburg Manufacturing Corporation, Pittsburgh, Pennsylvania.

"Survey of the Iron Ore, Pig Iron and Scrap Situation," by M. D. Harbaugh, Vice-President, Lake Superior Iron Ore Association, Cleveland, Ohio.

1:30 P.M. — MECHANICAL DIVISION — Cardinal Room.

Chairman:
E. W. TREXLER
Superintendent Mechanical Department
Bethlehem Steel Company
Cambria Plant, Johnstown, Pennsylvania

Vice-Chairman:
C. J. DUBY
Chief Engineer — Warren District
Republic Steel Corporation
Warren, Ohio

"Application of Modern Cold Sawing Technique," by N. A. Malone, Plant Industrial Engineer, Steel and Tube Division, Timken Roller Bearing Company, Canton, Ohio.

"Development of Personnel in the Steel Industry," by Russell Greenly, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

"The Application of NE Steel," by John Mitchell, Metallurgical Engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

7:00 P.M. — INFORMAL STAG DINNER — Ball Room.

Thursday, September 24

9:00 A.M. — COMBUSTION DIVISION — Cardinal Room.

Chairman:
E. E. CALLINAN
Combustion and Refractory Engineer
Steel and Tube Division
Timken Roller Bearing Company
Canton, Ohio

Vice-Chairman:
C. J. WYROUGH
Superintendent Steam Efficiency and Combustion
Jones & Laughlin Steel Corporation
Pittsburgh, Pennsylvania

"Fundamentals of Open Hearth Design," by Fred Loftus, The Loftus Engineering Company, Pittsburgh, Pennsylvania.

"Relation of Flame Character to Open Hearth Operation," by A. J. Fisher, Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland.

"Developments in Steel Plant Refractories," by C. A. Brashares, Technical Department, Harbison Walker Refractories Company, Pittsburgh, Pennsylvania.

1:30 P.M. — COMBUSTION DIVISION — Cardinal Room.

Chairman:
E. C. McDONALD
Combustion Engineer
Republic Steel Corporation
Corrigan-McKinney Works
Cleveland, Ohio

Vice-Chairman:
FRANK C. FRYE
Steam and Fuel Engineer
Great Lakes Steel Corporation
Ecorse, Detroit, Michigan

"Determination of Blast Furnace Gas Credits," by Frank E. Leahy, Superintendent of Fuel Department, Youngstown Sheet and Tube Company, Youngstown, Ohio.

"Modern Turbine Types and Design," by F. K. Fischer Central Station Steam Engineer, Westinghouse Electric and Manufacturing Company, Philadelphia, Pennsylvania.

Round Table Discussion — Steel plant fuel supplies.

1:30 P.M. — LUBRICATION DIVISION — Forum Room.

Chairman:
C. R. HAND
Lubrication Engineer
Bethlehem Steel Company
Sparrows Point, Maryland

Vice-Chairman:
P. J. DOYLE
Lubrication Engineer
Republic Steel Corporation
Cleveland, Ohio

"The Use of Addition Agents in Petroleum Products," by F. F. Musgrave, Assistant to Director of Research, The Lubri-Zol Corporation, Cleveland, Ohio.

"Bearing Surfaces," by E. L. Hemingway, Chief Metallurgist, International Machine Tool Corporation, Elkhart, Indiana.

"Turbine Lubrication," by Stanley O'Dette, Senior Field Engineer, Standard Oil Company of New Jersey, New York, New York.

...a real contribution to vital war production...*

UNITED STATES STEEL CORPORATION
OF DELAWARE

436 SEVENTH AVE.
PITTSBURGH, PA.

B F FAIRLESS
PRESIDENT

August 12th, 1942.

Association of Iron and Steel Engineers
Empire Building
Pittsburgh, Pennsylvania

Gentlemen:

I am happy to join with the subsidiary companies of the United States Steel Corporation in extending to you a hearty welcome to Pittsburgh on the occasion of your annual meeting here from September 22-24 inclusive.

I am interested to note that in view of present conditions you have elected to forego the usual exhibits and other activities which ordinarily attend your convention, and that you will concentrate on the more serious aspects of an engineering conference.

* The exchange of ideas, which attends the type of conference you plan, is a real contribution to vital war production, and I know will go far toward bringing about victory through production, to which all units in our industry are pledged in these grave times.

We welcome you to Pittsburgh and wish for your organization a successful meeting which will result in greater achievements for our industry in its service to our country.

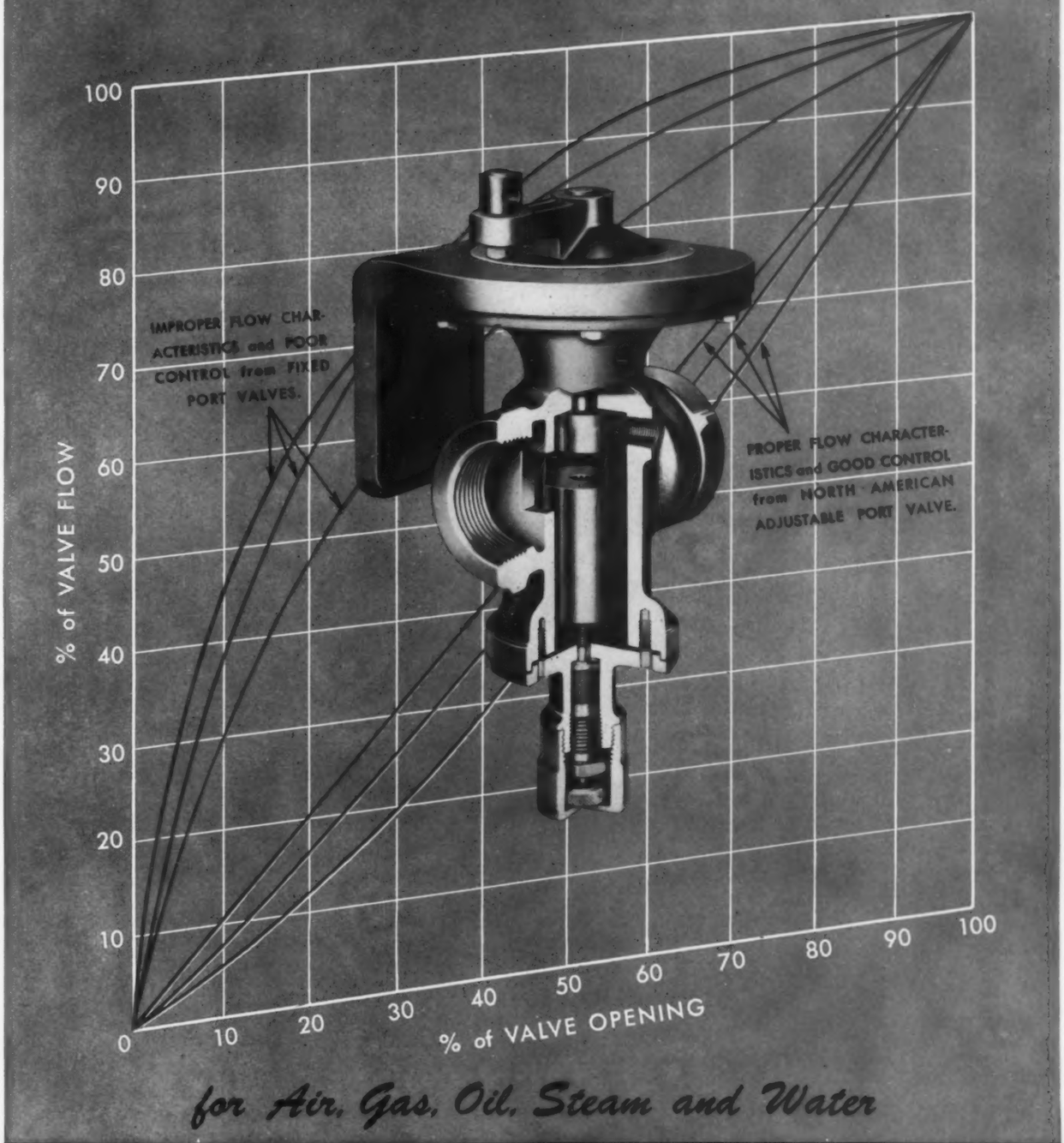
Sincerely yours,

B F Fairless

President.

NORTH AMERICAN

Adjustable Port Valves for Flow Control



for Air, Gas, Oil, Steam and Water

THE NORTH AMERICAN MANUFACTURING COMPANY

MANUFACTURERS OF INDUSTRIAL FUEL BURNING EQUIPMENT FOR GAS OR OIL

BRANCH OFFICES *with* FIELD ENGINEERS *in* PRINCIPAL CITIES

CLEVELAND, OHIO

...a real contribution to vital war production...*

UNITED STATES STEEL CORPORATION
OF DELAWARE

436 SEVENTH AVE.
PITTSBURGH, PA.

B F FAIRLESS
PRESIDENT

August 12th, 1942.

Association of Iron and Steel Engineers
Empire Building
Pittsburgh, Pennsylvania

Gentlemen:

I am happy to join with the subsidiary companies of the United States Steel Corporation in extending to you a hearty welcome to Pittsburgh on the occasion of your annual meeting here from September 22-24 inclusive.

I am interested to note that in view of present conditions you have elected to forego the usual exhibits and other activities which ordinarily attend your convention, and that you will concentrate on the more serious aspects of an engineering conference.

* The exchange of ideas, which attends the type of conference you plan, is a real contribution to vital war production, and I know will go far toward bringing about victory through production, to which all units in our industry are pledged in these grave times.

We welcome you to Pittsburgh and wish for your organization a successful meeting which will result in greater achievements for our industry in its service to our country.

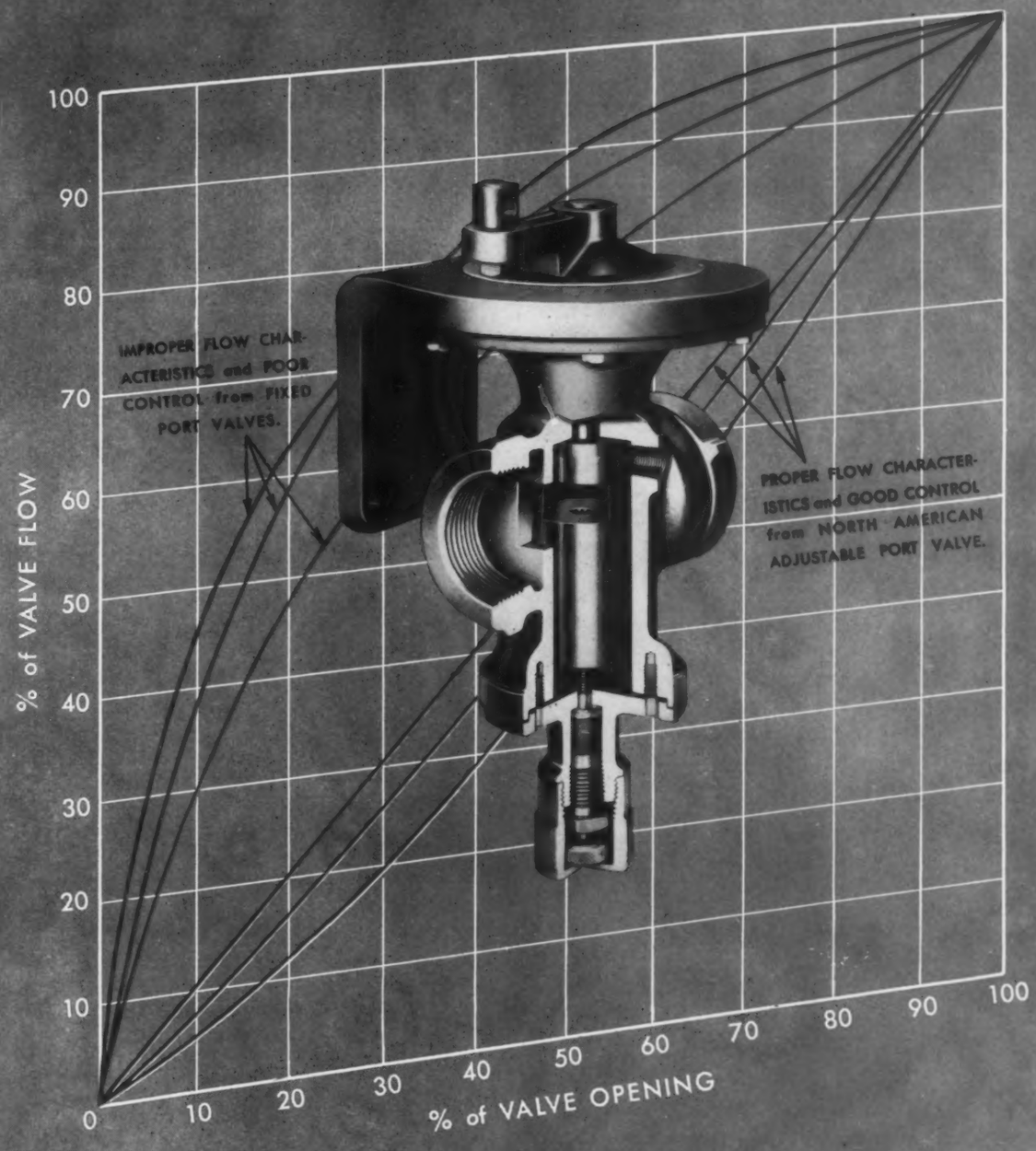
Sincerely yours,

B F Fairless

President.

NORTH AMERICAN

Adjustable Port Valves for Flow Control



for Air, Gas, Oil, Steam and Water

THE NORTH AMERICAN MANUFACTURING COMPANY

MANUFACTURERS OF INDUSTRIAL FUEL BURNING EQUIPMENT FOR GAS OR OIL

BRANCH OFFICES *with* FIELD ENGINEERS *in* PRINCIPAL CITIES

CLEVELAND, OHIO

LEWIS

Up and Down cut SHEAR

LEAVES THE SLAB STRAIGHT AND TRUE AFTER CROPPING

This new 1350-ton Lewis Heavy Duty Cold Slab Shear is saving time on the Victory Program.

LEADING FEATURES

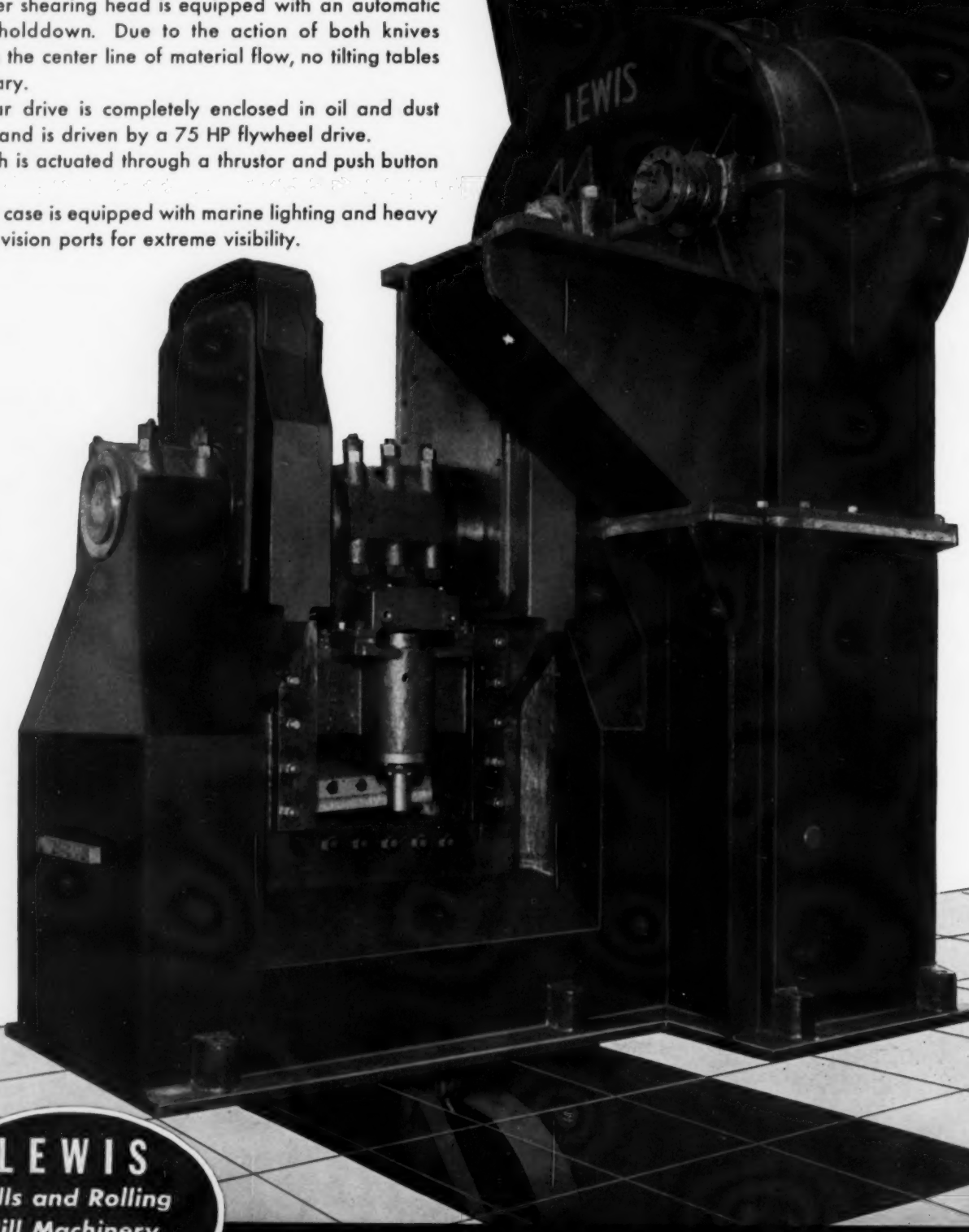
This shear is designed to crop 3" x 25" slabs. Both upper and lower knives function in vertical slides eliminating oscillation of the main cutting frame and assuring a true cut and straight slab after cropping.

The upper shearing head is equipped with an automatic hydraulic holddown. Due to the action of both knives meeting on the center line of material flow, no tilting tables are necessary.

The shear drive is completely enclosed in oil and dust tight cases and is driven by a 75 HP flywheel drive.

The clutch is actuated through a thrustor and push button control.

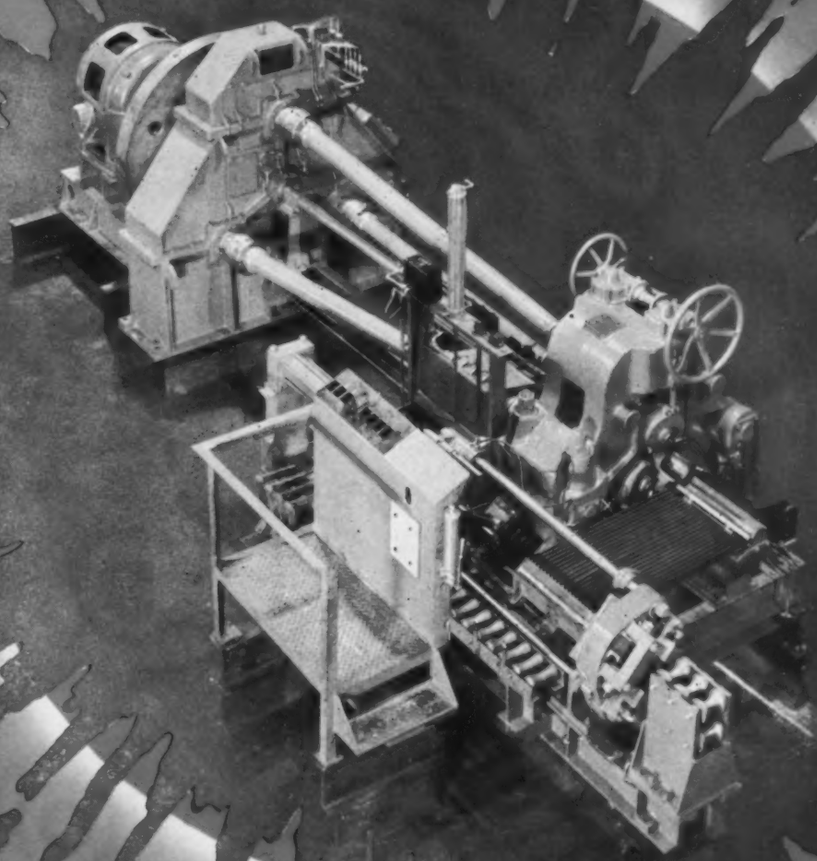
The gear case is equipped with marine lighting and heavy plate glass vision ports for extreme visibility.



LEWIS
Rolls and Rolling Mill Machinery step up tonnage

LEWIS FOUNDRY & MACHINE
DIVISION OF BLAW-KNOX CO.
PITTSBURGH, PA.

EXPLODING
ALL PRODUCTION RECORDS



Witter Mills have rolled peak hourly productions as . . . . . .

425 75 m.m. 290 105 m.m.
220 155 m.m.
(from actual records)

Let us explain how you can start with a minimum weight billet or 25% less steel and eliminate the rough machining operation.

SALEM ENGINEERING COMPANY

SALEM ENGINEERING CO., SALEM, OHIO

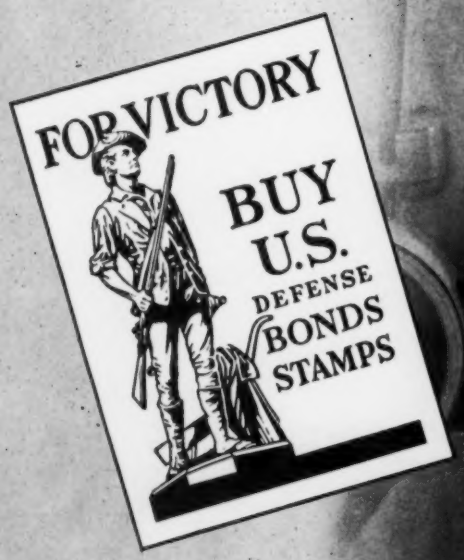
ANOTHER

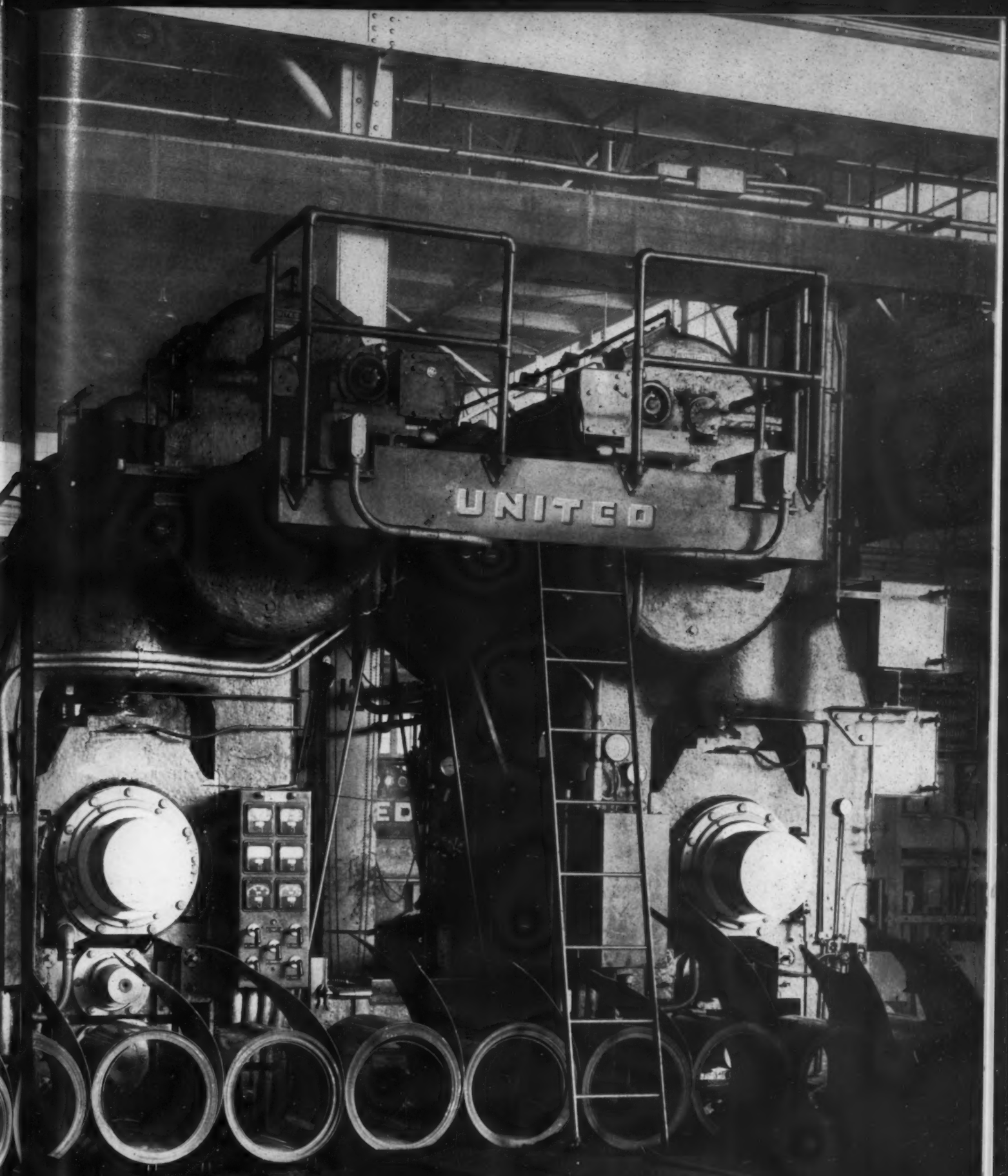
UNITED

INSTALLATION

ROLLING FOR

VICTORY



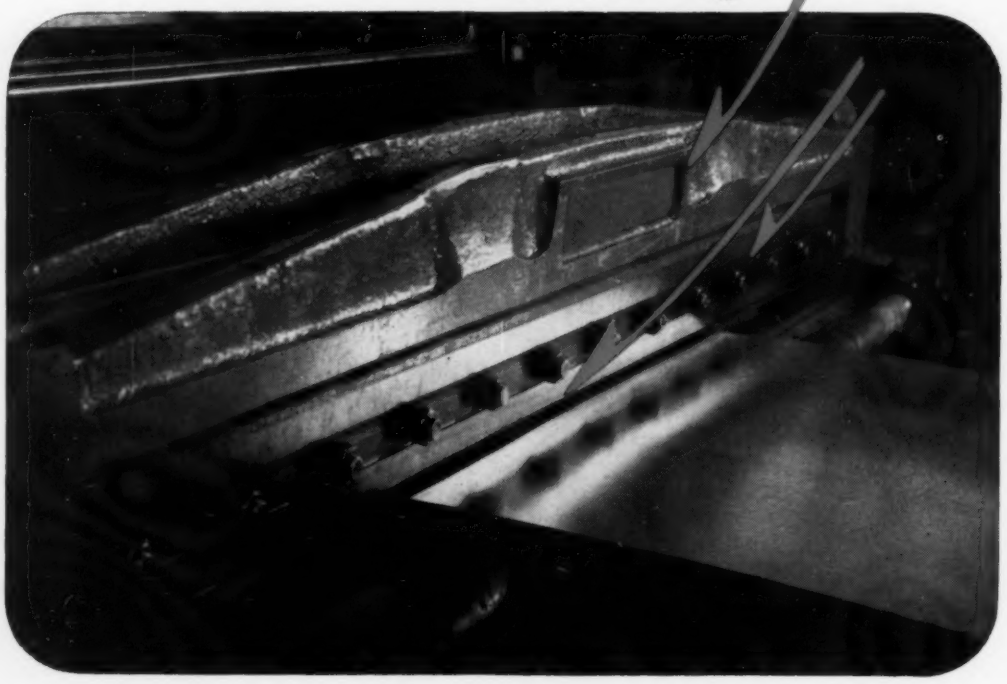


UNITED ENGINEERING *and* FOUNDRY COMPANY

Pittsburgh, Pennsylvania

Save Time and Money

here



with Heppenstall Shear Knives

Heppenstall Shear Knives require less grinding and deliver more cuts to the grind because they are made of special analysis alloy steel in Heppenstall's own electric induction furnaces according to methods developed through more than fifty years of quality shear knife manufacture.

Without any obligation, Heppenstall Engineering Service will gladly help you solve shear knife problems. And next time you order, specify Heppenstall. Use knives whose guaranteed high quality save you time and money. Write for full information, Heppenstall Company, Box E5, 4620 Hatfield Street, Pittsburgh, Pennsylvania.

Heppenstall

PITTSBURGH · BRIDGEPORT · DETROIT

HEPPENSTALL H QUALITY

Forging Fine Steels For More Than Fifty Years

IN THE *Groove!*

OHIO ROLLS

CARBON STEEL ROLLS
ALLOY STEEL ROLLS
PLAIN CHILLED IRON ROLLS
ALLOY IRON ROLLS
MOLYBDENUM CHILL ROLLS
NICKEL CHILL ROLLS
FLINTUFF ROLLS
DENSO-IRON ROLLS
HOLL-O-CAST ROLLS

THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO — SPRINGFIELD, OHIO

Save Time and Money

here

with Heppenstall Shear Knives

Heppenstall Shear Knives require less grinding and deliver more cuts to the grind because they are made of special analysis alloy steel in Heppenstall's own electric induction furnaces according to methods developed through more than fifty years of quality shear knife manufacture.

Without any obligation, Heppenstall Engineering Service will gladly help you solve shear knife problems. And next time you order, specify Heppenstall. Use knives whose guaranteed high quality save you time and money. Write for full information, Heppenstall Company, Box E5, 4620 Hatfield Street, Pittsburgh, Pennsylvania.

Heppenstall

PITTSBURGH · BRIDGEPORT · DETROIT

HEPPENSTALL H QUALITY

Forging Fine Steels For More Than Fifty Years

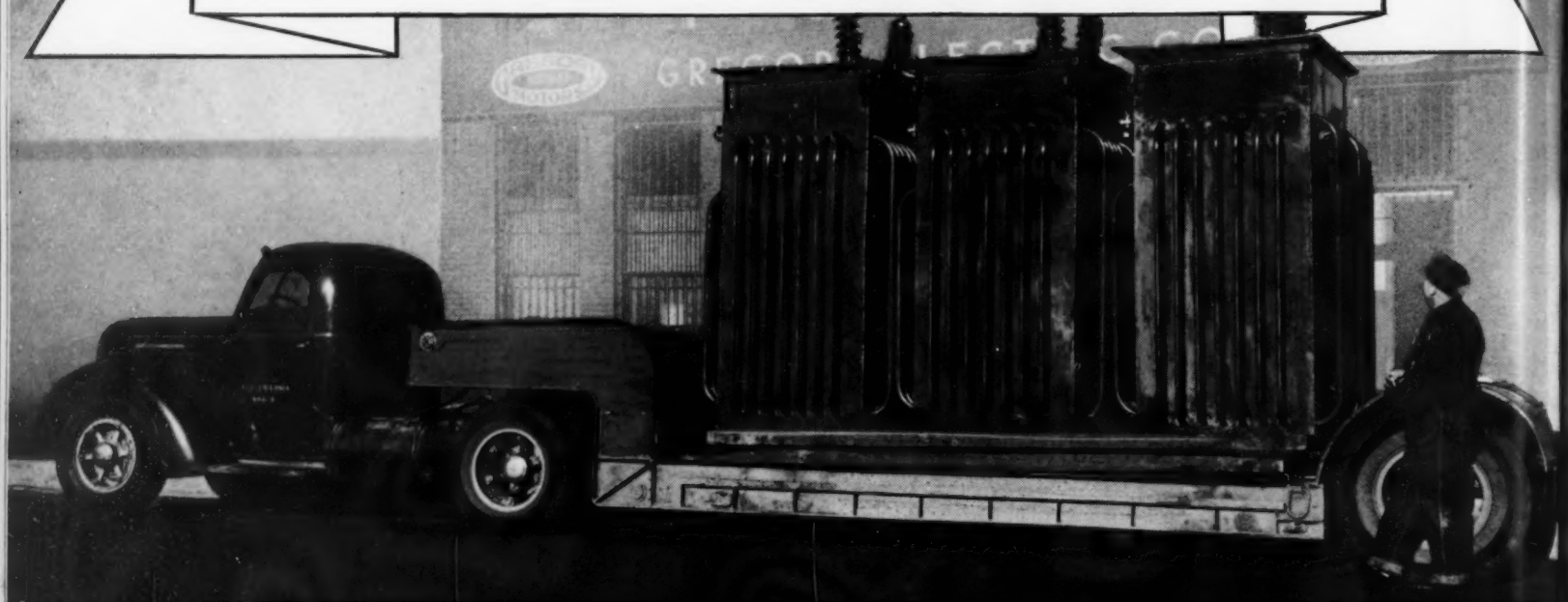
IN THE *Groove!*

OHIO ROLLS

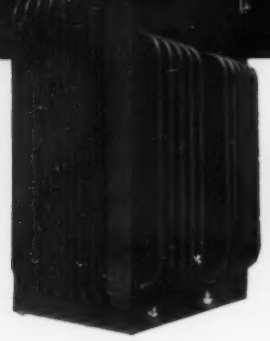
CARBON STEEL ROLLS
ALLOY STEEL ROLLS
PLAIN CHILLED IRON ROLLS
ALLOY IRON ROLLS
MOLYBDENUM CHILL ROLLS
NICKEL CHILL ROLLS
FLINTUFF ROLLS
DENSO-IRON ROLLS
HOLL-O-CAST ROLLS

THE
OHIO STEEL FOUNDRY CO.
LIMA, OHIO SPRINGFIELD, OHIO

KILOWATTS SAVED FOR WAR PRODUCTION



. . . because Gregory Electric Transformers are safeguarded with this dependable and permanent extra protection!



DOLPH'S CHINALAK INSULATING VARNISH

NO greater responsibility rests on any other unit of industrial equipment than that imposed on transformers. All the vast production and assembling facilities, now engaged in the Ordnance Program, are dependent upon this equipment for energy and proper functioning.

Gregory Electric transformers are precision engineered for peak-performance year after year. Here again, the insulation has the extra protection afforded by DOLPH'S CHINALAK Baking Varnish.

CHINALAK, particularly recommended for use where corrosive actions on insulation are prevalent, has exceptional oilproof qualities. It has excellent acid and alkali resistance, and will not crack nor become brittle when subjected to heat under normal operating conditions. A single coat, with a build-up of 2½ to 3½ mils, has a dielectric value of over 1300 volts per mil.

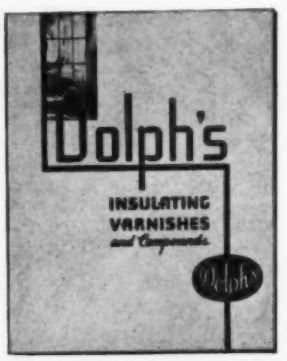
For extra protection at all times, under all conditions, specify CHINALAK . . . its your assurance of dependability.

INSULATING VARNISHES FOR EVERY PURPOSE

There's a DOLPH insulating varnish for every electrical requirement, which will add years of uninterrupted service to equipment. Prolong the life of your electrically-operated products by insuring against insulation failures. Write today for the 40-page Catalog describing the complete DOLPH line of insulating varnishes; there's no obligation, of course.

OUR POST WAR SERVICE

DOLPH'S Insulating Varnishes are obtainable during the emergency for vital work. As is the case with all other manufacturers, civilian needs must, of necessity, wait. However, our chemists are available for collaboration on all varnish insulation problems now, whether in the production or planning stage. Inquiries invited.



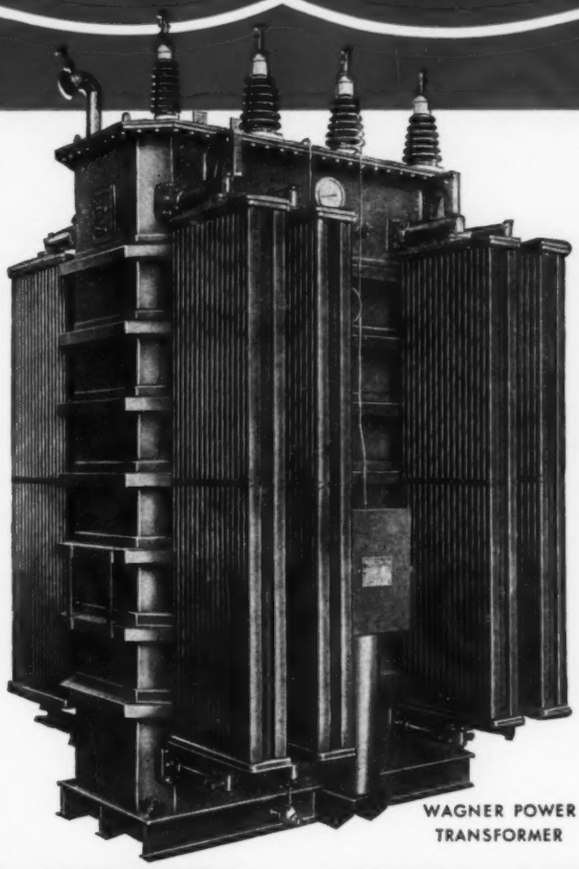
Dolph's

JOHN C. DOLPH COMPANY

Insulating Varnish Specialists

166-A EMMET STREET NEWARK, NEW JERSEY

The "EXTRA MARGIN OF SAFETY" built into WAGNER TRANSFORMERS gives ADDED PROTECTION!



WAGNER POWER TRANSFORMER

WAGNER NOFLAMOL TRANSFORMER

WAGNER AIR-COOLED TRANSFORMER

WAGNER HEX TRANSFORMER

The steel industry, in its effort to keep production rolling at top speed, is imposing extra loads on all production equipment. Transformers are no exception—they too must be able "to take it", and "come up smiling."

Liberal insulation—extra end turns on coils provide liberal protection against line surges and voltage disturbances . . . Heavy tank construction—heavy steel plate, electrically welded, sand-blasted and flow-painted . . . Core iron of non-aging silicon steel—has high magnetic permeability and has very low hysteresis and eddy-current losses . . . Stationary contacts—of hard-drawn copper, sweated and pinned into brass-shouldered studs . . . Bushings—wet-processed porcelain, either solid or oil-filled with sufficient mechanical and electrical strength to carry the load without puncturing . . . Transformer oil—has high dielectric strength, proper viscosity, safe flash-point, and will not sludge.

These are just a few of the superior characteristics of Wagner Transformers which give that "Added Margin of Safety". In addition, carefully controlled production methods, rigid inspection, plus 50 years of transformer engineering experience, assure users of Wagner Transformers the highest efficiency and stamina so necessary for the demands of today's stepped-up production.

No matter what your transformer requirements may be, the Wagner line will meet your requirements. Wagner Transformers range from small air-cooled to large oil-filled power transformers—and the same high quality goes into the construction of each one.

SEND FOR COMPLETE LITERATURE TODAY!

WAGNER ELECTRIC CORP., ST. LOUIS, MO., U. S. A.

T42-10
I&SE

Gentlemen:
Please send me bulletins TU-180 and TU-181.

Name_____ Position_____

Firm_____

Address_____

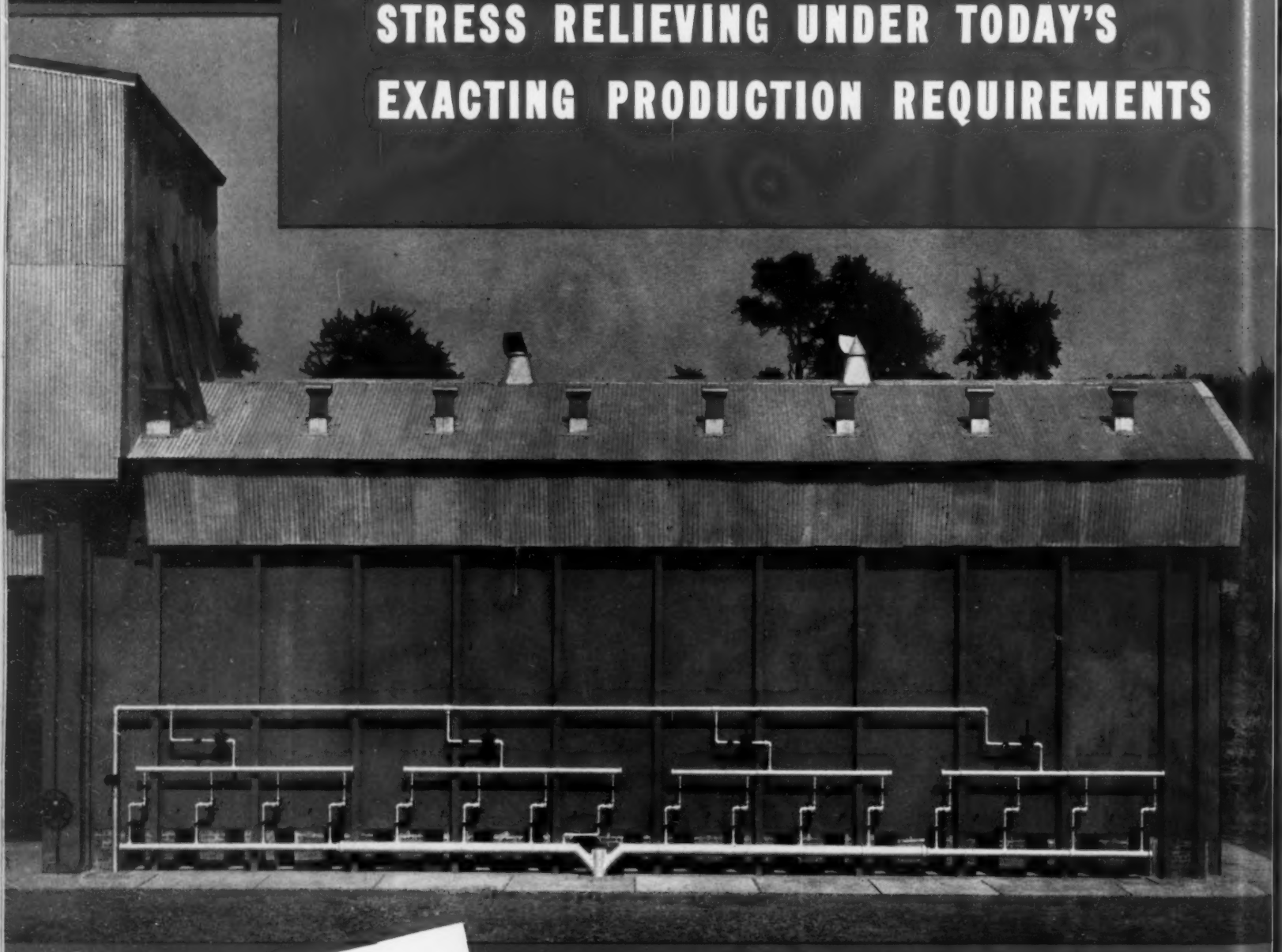
City_____ State_____

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

TRANSFORMERS • MOTORS • FANS • BRAKES

A TYPICAL SWINDELL GAS FIRED CARBOTTOM FURNACE FOR PRECISION-CONTROLLED HEAT TREATING AND STRESS RELIEVING UNDER TODAY'S EXACTING PRODUCTION REQUIREMENTS



A RECENT INSTALLATION
9' x 48' x 12' ... AT THE
NATIONAL ANNEALING
BOX COMPANY
WASHINGTON, PENNA.

SWINDELL

SWINDELL • DRESSLER *Corporation*

DESIGNERS AND BUILDERS OF MODERN FURNACE EQUIPMENT SINCE 1850

PITTSBURGH, PA.

RECOVERY and PREPARATION of Steel Scrap from Steel-Making Furnace Slag & Refuse

By Fred E. Ullman

THE HECKETT CORP.

BUTLER, PENNSYLVANIA

Presented at

A. I. S. E. DETROIT DISTRICT SECTION

...thankful for the waste of former years, the steel industry turns to magnetic separation to recover precious metallics from refuse and slag dumps...

▲ IT IS well known to all steel makers that free steel in metallic form is lost in the slag and pit refuse in modern steel making operations. The physical characteristics of this lost metal range from the commonly-recovered ladle skulls, tap hole drippings, large pieces of pit scrap, and sizeable buttons from the bottom of slag thimbles, down to minute droplets of metal which may be bound up inside solid pieces of slag or which splash out of the ladles at the time of tapping, giving the effect of many sparks, each of which is, in reality, a particle of steel. For many years steel makers have been aware of these losses of free metal and have devised methods and installed equipment for the purpose of recovering that portion which could be recovered economically and which may be recharged into the furnaces as cold scrap. This paper deals with further advanced economical methods for the recovery of the metal, and with the preparation of the recovered scrap to a higher average quality than has heretofore been effected.

It is only logical that attention to the recovery of usable free steel in slag and refuse should have first been given in Europe, due to the fact that raw materials there are more scarce and consequently higher priced. Prior to 1920 some attention had been given to the possibility of recovering permeable metallics in small sizes from various diluting materials by means of magnetic separating equipment. This principle was considered about that time, particularly in the light of its possible application to the recovery of metallics in foundry sand and even in open-hearth slag. In the early 20's several installations were made in various parts of Europe specifically for the purpose of recovering the permeable metallic gates, risers, etc., present in foundry sand, and experiments were made along the same line in effecting a similar recovery of free steel from steel making furnace slags. In 1927 E. H. Heckett, now president of The Heckett Corporation and Heckett Engineering, Inc., became interested in the application of the magnetic separating principle to the recovery of the metallics contained in foundry and steel plant slag and refuse, and began constructing and operating recovery plants. By 1938 a total of 20 installations had been made in various European foundries and steel plants by his company. It is interesting to note that the European recovery operations were of such importance to the various steel makers and foundrymen that arrangements were made by them to permit Mr. Heckett's Dutch company to operate in many of the European countries without the restrictions of blocked currency regulations.

By 1938 a preponderant number of the larger foundries and steel plants in Europe were equipped with comparatively efficient recovery installations, while at

Figure 1 — Dump slag and refuse are handled by shovel onto an inclined grizzly on the separating machine.

the same time visiting members of the American steel industry were becoming interested in the possibility of effecting more efficient recovery of metallics in American steel plants. It was at this time that Mr. Heckett came to the United States and investigated the possibilities for recovery operation in the American steel industry, consequently becoming acquainted with a number of American steel makers.

With the possible exception of the last world war period, there had always been a plentiful supply of steel scrap in America. As a result steel makers had not given serious consideration to recovery of losses of free steel in steel making furnace slags. Although a number of individual plants were operating slag docks and skull crackers, thereby enabling them to recover a portion of the steel lost in the slag and refuse, it was quite apparent that American steel makers had not recognized the full possibility inherent in the recovery of these lost metallics. The steel makers did not believe that sufficient quantities of steel were lost in the slag and refuse to warrant the installations necessary to recover these metallics. A number of the plants that were recovering some of the lost metallics found that the scrap was not of high enough quality to allow appreciable percentages to be charged in any one heat. Furthermore the steel makers were of the opinion that the metallics that were contained in the slag and refuse could not be prepared to such a quality. For these reasons little development of special equipment for recovering these metallics was undertaken by American steel makers. Because of this lack of interest it was difficult to arrange for an initial installation of a complete recovery and preparation operation.

It is interesting to note that there were no patents in existence covering the application of magnetic separating machinery for the recovery of permeable metallics from steel making furnace slag and refuse. There were patents on magnetic separating machinery used for the purpose of recovering permeable metallics, such as nails, nuts and bolts, etc., from material, such as grain, coal, etc., in which the metallics were considered impurities which it was necessary to remove for one reason or another. With the exception of numerous small installations of magnetic separating equipment for the recovery of permeable metallics from foundry sand and blast furnace slag in slag plants, little, if any, attention had been given to magnetic separation as applied to the recovery of usable permeable metallics with the intention of utilizing the recovered metallics as cold scrap. Consequently it was possible for Mr. Heckett to obtain patents covering the recovery and preparation of steel scrap from steel-making furnace slag and refuse.

The first recovery and preparation plant was erected in a midwest plant of one of the large steel companies. Due to the fact that the steel company was unwilling to sign a long-term contract without having first experienced the value of the recovery operation both as to quantity recoverable as well as to the quality to which the recovered steel scrap could be prepared, the first plant was erected for the purpose of recovering the steel contained in the pit refuse coming from the open-hearth furnace pits. The operation proved successful and resulted in a second operation in a southern plant belonging to the same steel company covered by a longer term contract. The second installation was designed for the purpose of recovering the steel scrap contained in an existing dump. By the time this operation had started producing, considerable interest was shown in the process by numerous other companies and four more plants have since been built and put into operation. Several more plants are being built at present and plans for more are under way.

Recovery and preparation operations are best divided under two general headings. The first is the dump operation involving the recovery and preparation of steel scrap from the slag and refuse contained in existing dumps. This type operation is particularly interesting to steel makers at the present time due to the fact that many of the old slag dumps contain high percentages of steel scrap which may be recovered and prepared in considerable quantities thereby alleviating the scrap shortage in the individual cases where such operations can be installed.

In the dump recovery operation all of the recovery equipment is readily portable. For this reason the magnetic separator is a specially built unit capable of handling 150 cu yd per hr, complete with its own power plant and built on skids or caterpillar treads in order that it may be moved as is necessary to follow the digging operation.

Figure 1 is a side view of the separator machine showing the side away from the edge of the dump where the digging operation takes place. In operation the

Figure 2 — The grizzly will pass pieces 12 in. or smaller into the hopper below.

Figure 3 — Another view of separation machine, taken from side facing the digging operation.

shovel picks up its load of slag and refuse from the dump and deposits the material approximately 1½ yd at a time, on an inclined grizzly which allows pieces of 12 in. in size or smaller to pass into the hopper beneath the grizzly. The actual loading operation is shown in Figure 2 and the oversize pieces which will not pass through the grizzly into the hopper below roll down on a chute to the ground in front of the machine where the larger steel pieces may be picked out either by hand or by means of a crawler crane equipped with a magnet. Referring to Figure 1, the material which has passed through the grizzly into the hopper below is fed to a bucket elevator which raises the material to a suitable height for gravity handling. The material from the bucket elevator is fed over a magnetic separating drum which removes the metallics and slag containing metallics from the slag and refuse. The slag chute is shown on the extreme right. The recovered metallics drop on a screen below the drum where a size separation is effected. The pieces passing through a ¾ in. mesh screen are brought through the chute shown immediately behind the truck shown in the foreground, and ultimately used in blast furnaces. The larger pieces which do not pass through the screen are brought out on the opposite side and ultimately used in steel making furnaces. The power plant and control equipment are located in the housing to the left of and below the slag chute.

Figure 3 is a side view of the machine taken from the dump and showing the side of the machine adjacent to the edge of the dump where the digging operation takes place. The slag chute on the extreme left and the chute carrying out the larger pieces of steel which will ultimately go to the steel making furnaces are shown. The position of the shovel is also shown and this position is such that the shovel can dig from the dump and load directly onto the grizzly over the hopper. The dump truck shown in the foreground is placed directly behind the shovel in order that the larger pieces of steel may be loaded directly on the dump truck by the shovel.

Figure 3 also illustrates the manner in which the slag and refuse is ordinarily disposed of. The slag and refuse is usually allowed to drop on the ground from the slag chute and pushed away by means of a caterpillar type tractor equipped with a bulldozer. In cases where the space for rebuilding the dump of worked through slag and refuse is not sufficient, a special tractor is used which is equipped with a large bucket. With this unit the slag and refuse falling on the ground from the slag chute may be picked up and carried up a much steeper grade than is possible in the bulldozer operation. The lip of the slag chute is approximately 8 ft above the ground level and in many cases the worked through slag and refuse is loaded directly into trucks and hauled to fill jobs. Where disposal of waste by means of tractors is impossible, the entire output of slag and refuse from the machine may be loaded in trucks and transported to any desired location.

Figure 4 illustrates the manner in which the recovered steel and slag containing steel are handled. The position of the dump truck behind the shovel shown in Figure 3 is also shown in this figure. Projecting from the right and left of the machine are the steel scrap and blast furnace fines chutes respectively. Beneath these chutes are placed pans which may be handled by the pan hoist truck also shown in Figures 1 and 4. When these pans are filled they are picked up by the truck, pulled out from beneath the chutes, empties replaced under the chutes, and the full pans carried to the respective stocking points. A hand operated gate is mounted in the slag chute which permits the separator machine operators to shut off the flow of slag coming down the slag chute while a tractor or truck passes beneath the chute in transporting the worked through slag and refuse away from the machine. Smaller gates are also mounted in the steel scrap and fines chutes in order that the flow of these materials may be stopped while the pans beneath the chutes are being replaced. These gates permit the continuous operation of the machine irrespective of transportation operation.

Due to the necessarily high strength of the magnetic drum, all materials which could be picked up with a 65 in. industrial magnet are recovered and are led out of the machine in either the fines or steel scrap chutes. These materials consist not only of steel pieces, but also of the magnetic slags contained in the dump. As a result a large percentage of the materials coming out of both the fines and steel scrap chutes consist of pieces of magnetic slag containing no free metal, but made up largely of magnetic oxides. Since the average analysis of the fines for blast furnace use is below 40 per cent Fe, it is necessary that these fines be stocked and rerun through the separator machine. During the rerunning of the fines the voltage on the magnetic drum is adjusted to exclude any desired portion of the fines. By means of such adjustment the analysis of the rerun fines can be controlled to the extent that the final analysis of the fines may be brought up as high as 80 per cent Fe. In cases where the analysis of the slag adhering to the fines is not too high in oxides not desirable in the blast furnaces, it is often desirable to charge the fines as they come out in the first run. This applies particularly where the recovery operation is close enough to the blast furnaces to minimize the transportation costs. The fines ready for shipment to the blast furnaces are caught in pans as illustrated above, transported by the pan hoist truck to a railroad

Figure 4 — Illustration showing manner in which recovered steel and slag containing steel are handled.

siding, and dumped directly into hopper cars for delivery to the blast furnace.

Figure 5 illustrates a typical preparation unit consisting of an overhead crane, a breaking pit for breaking down large pieces of steel to charging box size, a cleaning installation, and a siding under the runway for loading out recovered and prepared scrap. The recovered steel scrap is brought in from the recovery operation from the extreme right and is dumped beneath the runway from the ramp under the right hand end of the runway. Two dumping chutes are located under the end of the runway, the lips of which are 6 or 8 ft above the ground to allow sufficient stocking space. The materials recovered through the separator and which come out of the steel scrap chute are dumped on one of these chutes while the larger steel pieces loaded directly onto a dump truck by the shovel are dumped on the other of the chutes. The larger steel pieces are picked up by the magnet operated by the overhead crane and broken down to charging box size by the skull cracker method. Thick pieces of pit scrap or large buttons from slag thimbles which cannot be broken by the skull cracker ball are lanced with an oxygen lance and blasted with dynamite. The large and small pieces are fed into the cleaning installation in approximately equal proportions for greatest efficiency in the cleaning operation. The cleaning installation is shown in the center of the runway and after cleaning, the steel scrap is dumped into a pit shown on the left of the cleaning installation and loaded in cars or charging boxes on the siding shown under the left end of the runway.

Figure 6 is an illustration of the cleaning installation which consists of large tumbling mills specially designed for the cleaning operation. These tumblers handle batches of approximately 6 tons at a time. The material is loaded in through the open top, the lid clamped on, and the tumblers rotated for sufficient period to give the desired analysis. After the cleaning has been completed the lids are removed and the tumblers dumped into the pits shown in Figure 6. These pits are specially designed so that the material falling out of the tumblers is separated into two component parts. The tumbling action breaks down the majority of the adhering slag to granular size. Such removed and pulverized adhering slag makes up approximately 30 per cent of the total weight of the steel scrap charged into the tumblers. The tumbler pits below the rails shown in the figure, are designed so that the fine slag drops immediately below the rails while the steel is carried farther out away from the base of the rails. The magnetic slag which has been recovered by the separator and fed into the tumblers is also broken down to granular size and is also separated from the prepared scrap when the tumblers are dumped.

Due to the extreme flexibility of the recovery equipment, recovery operations may be undertaken under almost any physical conditions. The type of recovery equipment described above can operate in any but the most confined areas and the transportation equipment is adequate to handle any disposal of the waste and the transportation of the recovered steel over any kind of terrain. Due to the fact that the transportation costs do not ordinarily exceed 15 per cent of the total cost of recovery and preparation in the average operations, the stationary preparation unit may be located some distance away from the site of the recovery operation. In all cases this distance varies due to the fact that the recovery equipment is portable and moves, during the course of the recovery job, all over the area occupied by the dump. In cases where adequate power and rail transportation facilities are not available, portable power generation equipment may be employed with slight increase in production cost and trucks may be employed to transport the recovered and prepared steel scrap from the site of the recovery and preparation job to rail transportation facilities or directly to the steel plant.

At present dump recovery operations are limited largely to clean steel-making furnace slag dumps containing from 12 to 18 per cent of recoverable steel scrap and delivering from 2000 to 3000 tons per month of prepared scrap with each set of equipment described above. However, there is no reason why, if the scrap shortage continues, the recovery operations might not be started on dumps containing lower percentages of steel provided the steel makers are willing to pay the price of recovery. In present operations the cost of recovery and preparation ranges between $6 and $9 per gross ton and in dumps containing as low as 6 per cent of recoverable steel the cost might rise above $20 per gross ton. These cost figures depend largely upon labor cost and the physical conditions under which the recovery operation is performed. The preparation cost generally remains constant for all operations.

In analyzing recovery and preparation cost of dump operation it is interesting to note that amortization and maintenance costs are exceptionally high. This condition is due to the fact that standard equipment, such as shovels, tractors, trucks, etc., must be used for this type of work. The steel making furnace slags are among the most heavy and abrasive materials known which are handled by this type of equipment. Accordingly the life of the equipment is considerably shorter than is the case in the operations where similar units are handling dirt, rock, etc., and maintenance costs are several times those encountered in most other operations.

The second general type of recovery and preparation job is the current production operation. This type of operation differs from the dump operation described

above in that all of the equipment is stationary. In the current production operation the recovery and preparation work is performed upon the slag and refuse being currently produced by the respective steel making furnaces. The currently produced slag and refuse is taken from the furnaces to the current production recovery and preparation plant and disposed of in the usual manner by the respective steel plant equipment.

The equipment used in the current production is, with the exception of the separator machine and the cleaning installation, the same type of equipment used today by many of the steel plants for the recovery operations on the steel making furnace slag and refuse as they are being performed. The slag and refuse, usually in thimbles and side dump cars respectively, is brought under an overhead crane runway and dumped into a hot slag pit. With a drop ball these materials are broken up in this pit and fed through a separator similar to the one illustrated in the above described dump operation by use of a modern clamshell bucket. The slag and refuse coming out of the slag chute is directed into railroad cars or trucks and removed to the dump. This type of operation necessitates only one bucket handling of the slag and refuse, from the hot slag pit to the separator grizzly, since the cars are reloaded by gravity from the separator slag chute. The handling of the slag and refuse from the hot slag pit is made efficient due to the fact that the slag and refuse which has not been broken down to a size which will pass through the separator is deposited in front of the separator grid in a concentrated pile where it may be broken most efficiently with the drop ball. By this method the larger pieces of steel which will not pass through the separator are also concentrated in front of the separator grizzly. In many cases it is necessary to cool the slag with water before feeding it through the separator and this operation aids greatly in breaking up the hot slag by use of water, and developments indicate that all of the slag can be broken up in this manner to small sizes which will allow maximum efficiency in bucket operation as well as in separation.

The steel scrap and blast furnace fines recovered by the machine are fed by gravity into storage pits under the runway where the fines may be stored for rerunning through the separator and ultimate shipment to blast furnaces, and where the recovered steel scrap may be picked up directly by a magnet on the crane hook and fed into the cleaning installation.

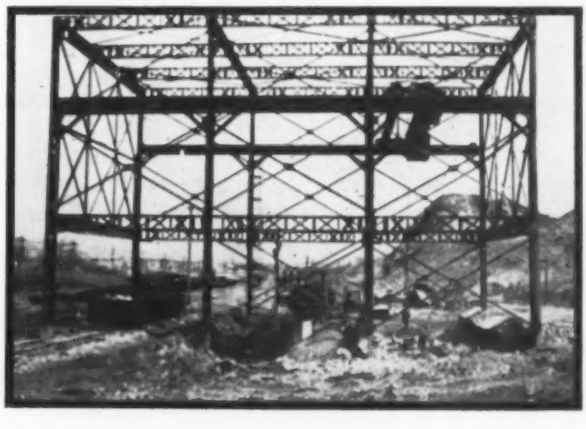
Where a blast furnace is operating near the steel plant the slag coming from the slag chute may be led through a crusher and crushed down to size suitable for use in the blast furnace as a fluxing material. In such a case the slag from the thimbles is dumped into a separate part of the hot slag pit in order that it may be fed separately from the pit refuse through the separating unit, crushed, and dropped directly into cars for shipment to the blast furnace.

There is reason to believe that crushed slag of this type could also be used for aggregates of various types. It has been applied particularly in Europe to road building materials due to the fact that it is structurally stronger than blast furnace slag and will not absorb as much tar, road oil, or asphalt as does blast furnace slag because of its greater porosity. In the southern steel-making areas where high-phosphorous open-hearth slags are produced, the slags are at present also being used for fertilizer. There are undoubtedly many further uses to which crushed open-hearth or bessemer slag could be put which have not been developed due to the fact that formerly these materials could not be crushed because of the adhering steel. Steel-free slag can be crushed readily in standard crushing equipment without breakage to the crushers.

The current production operation is extremely adaptable to most steel plant operations. For those steel plants which already have recovery operations consisting of overhead cranes on runways under which currently produced slag and refuse is dumped, it is often a relatively simple matter to add the installation of separating and cleaning equipment. The small amount of space occupied under the runways by these units is more than compensated for by the increase of efficiency in the operation of the present equipment. It is also often possible to bring other steel containing wastes into a complete current production recovery and preparation plant for the recovery of the scrap contained in them. This applies particularly to soaking pit scale, roller scale, foundry slag, foundry sand and other similar materials. Due to the fact that the current production recovery and preparation plants are usually in the vicinity of the steel making furnaces, the recovered and prepared steel scrap is loaded directly into charging boxes with a resulting saving in time and handling expense to the steel makers.

The cost of the recovery and preparation of steel scrap from the currently produced slag and refuse depends entirely upon the character of the materials being handled. The average loss into the slag and refuse at the furnace runs between 3 and 6 per cent of the ingot production of the furnace depending largely on the type of furnace and method of operation in use by the steel makers and 95 per cent of this loss can be recovered by use of the above outlined process. The cost to recover and prepare the steel scrap contained in these materials may range from $2 to $15 per gross ton. There are many reasons for this wide range. Where individual steel plants have various types of recovery

Figure 5 — The typical preparation unit consists of overhead crane, breaking pit, cleaning installation, and a loading siding.



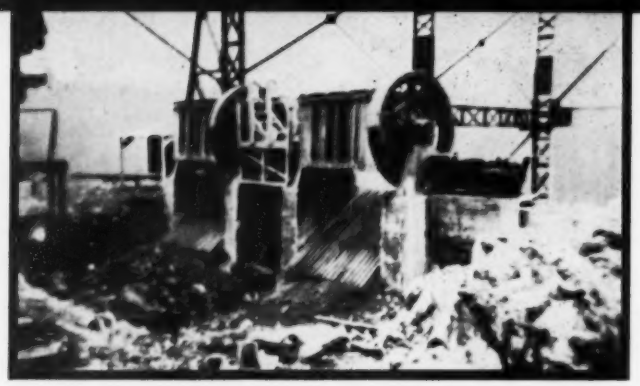


Figure 6 — The cleaning installation consists of large tumbling mills specially designed for the cleaning operation.

operations going on, the materials which might be worked through by a current production recovery operation would contain a low percentage of steel with a resulting high cost per ton for recovery and preparation. A number of the steel plants are of relatively small size and are accordingly not producing large quantities of slag and refuse. Since any complete recovery and preparation plant requires equipment of adequate size to effect the complete recovery and preparation job, it may not be necessary to operate the equipment more than five or six hours per day to process the volume produced, and therefore the amortization costs make up a high percentage of the total cost per ton. In adapting special recovery and preparation equipment to present recovery equipment operated by individual steel plants, it is often necessary to make special outlays involving extensive installations of conveying equipment. In general the cost per ton of labor and maintenance in the current production operation makes up a smaller percentage of the total cost per ton due to the fact that less labor is necessary and because the separator machine and the cleaning equipment is specially built to handle the heavy and abrasive materials encountered in this operation.

Since one of the major objections to the use of steel scrap contained in steel making furnace slag and refuse has been the low quality of the scrap which has formerly been recovered, the quality of the scrap recovered and prepared by the methods described above are of interest to steel makers. With the exception of the best quality pit scrap and ladle skulls, the steel scrap lost with the slag in tapping the furnaces contains only approximately 50 per cent steel by weight due to adhering slag. The steel scrap recovered and prepared as described above is composed of approximately 85 per cent steel by weight, and the analysis can be raised beyond this point where necessary in special steel making operations. Although many steel makers do not consider steel scrap of 85 per cent metallic content by weight to be a high quality scrap, present users of the scrap recovered and prepared to this quality by the above described methods indicate that no serious trouble is being encountered in the utilization of this scrap in the steel making furnaces. What disadvantages there may be in charging this type of scrap are, in many cases, offset by the fact that charging time is substantially decreased. The decrease of charging time is due to the fact that this type of scrap is exceptionally heavy and lends itself readily to efficient filling of charging boxes since the individual pieces vary in size from those which will not pass a 1 in. mesh screen up to full charging box size.

Of further interest to steel makers is the possibility of more accurate loss analysis calculations than have heretofore been possible. In calculating loss analysis, it has been impossible to make accurate determinations of the losses of free steel into the slag and oxidation into furnace gases. For the most part these two items remain the only unknowns in the loss analysis calculation since the oxide losses into slag could be determined. With a complete current production recovery and preparation operation, the loss of free metal into the slag and refuse is accurately determined, since all but the very small particles of steel widely distributed into the slag are recovered.

Due to the present scrap shortage, the recovery, and desirable preparation of steel scrap assumes an important position in the defense program. For this reason the War Production Board and the Reconstruction Finance Corporation have lent their help in expanding recovery operations of the type described above. A number of recovery plants have been and are being built for the Reconstruction Finance Corporation's Defense Plant Corporation. Because of the expansion of these recovery activities at the present time many steel makers are inclined to regard this type of operation as a temporary partial relief to the scrap shortage and one which will cease after the steel and scrap industries have returned to normal. In the few individual cases of those steel plants operating relatively efficient recovery equipment, this belief may be partially justified.

It is however important to recognize the fact that, until present steel making methods are changed radically, some loss of free metal in currently produced slag and refuse may be considered an inherent part of present day steel making operation. It has been definitely proven that the type of recovery installation, consisting of an overhead crane with magnet and bucket is a sound investment when used for the purpose of recovering that portion of the metallic loss which can be recovered by this method. It is then only logical that improvements in former methods for recovering this loss of free steel, when economically justified, should become a part of the recovery operation. In the average case a present day steel plant recovers from 50 to 75 per cent of the free metallics lost in the slag and refuse. Even though this percentage may be higher in some cases, there are few, if any, exceptions where the installation of recovery equipment alone is not economically justified. The advantages to be gained by preparing the steel scrap recovered by any method to a higher analysis will be affirmed by any steel making furnace operator.

Although the processes described in this paper have proven entirely practical, efficient, and economically justified, considerable study is being given to possible improvements. The present industrial situation imposes difficulty on the development of new equipment which must be especially designed and built. However, there is reason to believe that many improvements will be made in equipment and methods during, and particularly after, the war. Such improvements will, consistent with the history of the American steel industry, result in increased production of a better product at a lower cost.

ASSOCIATION OF IRON & STEEL ENGINEERS

Specifications for

ELECTRIC OVERHEAD TRAVELING CRANES

FOR STEEL MILL SERVICE

ASSOCIATION OF IRON AND STEEL ENGINEERS

SPECIFICATIONS FOR

Electric Overhead Traveling Cranes

FOR STEEL MILL SERVICE

Foreword by F. W. Cramer

▲ IT HAS long been recognized that cranes for service in steel mills must be of strong, rugged construction in order to give service twenty-four hours a day and seven days per week. The manufacturers and the users of these cranes have been in close cooperation for many years, improving designs to meet the increasing demands for dependable equipment to serve the steel industry. Starting in 1910, the A. I. S. E. sponsored the first specifications for steel mill cranes. At this time, structural end trucks, railway motors, drum controllers, mechanical brakes and cast iron wheels with steel tiers were standard designs. In 1916 these specifications were revised to include cast steel end trucks and trolley frames, dynamic braking, limit switches, mill type motors, spur type gearing, rigid conductors and magnetic brakes listed as items in the standard design.

Another revision was made in 1919 in which strength of materials, factors of safety, rolled or forged steel wheels, diametral pitch for gearing, box type girders, magnetic shoe brakes and magnetic controls were incorporated. In 1929 a further revision was made which included many details and information sheets which could be used by the purchaser as a model for securing more uniform proposals from the builders. Many features pertaining to safety were included and also provisions for using anti-friction bearings which were being adapted for crane use.

On September 28, 1938 F. D. Egan, chairman of the A. I. S. E. Standardization Committee, submitted a request to the Board of Directors recommending that the Association sponsor a revision of the 1929 crane specifications, which request was approved and the following active members were appointed on the committee to make the revisions:

F. D. Egan, electrical superintendent, Bethlehem Steel Company, Lackawanna, New York, general chairman of standardization.

F. W. Cramer, electrical engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania, chairman.

James Farrington, superintendent, electrical department, Wheeling Steel Corporation, Steubenville, Ohio

H. J. Walters, assistant electrical superintendent, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

F. E. Kling, assistant chief engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

R. N. Thompson, mechanical engineer, Great Lakes Steel Corporation, Ecorse, Michigan.

R. E. Lewis, maintenance superintendent, Youngstown Sheet and Tube Company, Youngstown, Ohio.

I. N. Tull, electrical superintendent, Republic Steel Corporation, Cleveland, Ohio.

H. W. Neblett, development and new design engineer, Inland Steel Company, East Chicago, Indiana.

The first meeting of the committee was held January 16, 1939, and it was decided that the general plan of procedure would be to take up each item of the original specifications and modify it as seemed advisable. It was agreed that the specifications should be limited to heavy duty mill type overhead traveling cranes and that all cranes for special services such as charging, pit, stripper, ladle, gantry and ore bridges comply as far as possible.

At the meeting held February 28, 1939, it was suggested that each of the leading crane companies manufacturing heavy duty type cranes be requested to appoint a representative to act with the main committee, particularly in reference to such subjects as crane girder design, bearings, gears and other important mechanical details. A list of the crane companies' representatives is given below:

E. H. Windolph, Alliance Machine Company, Alliance, Ohio.

E. C. Rice, vice president, Whiting Corporation, Harvey, Illinois.

W. C. Heinle, Cleveland Crane and Engineering Company, Wickliffe, Ohio.

R. J. Wadd, Harnischfeger Corporation, Milwaukee, Wisconsin.

C. H. Schramm, chief engineer, Shaw-Box Crane and Hoist Company, Muskegon, Michigan.

H. W. Ball, assistant chief engineer, Morgan Engineering Company, Alliance, Ohio.

At the meeting held in Cleveland, June 23, 1939, a plan was developed to carry on researach work in reference to crane girder design and a special committee made the following report:

"In order to bring the subject of procedure to a head the original committee of members held a meeting to develop what seemed to be the right plan. Mr. Farrington made a motion to the effect that a research engineer be employed for a period of four to eight months, as the work might require, to review the information already available re methods of crane girder design and test data recorded; and analyze such girder designs as are submitted to him by the committee. After this work is completed the engineer is to submit a report giving the results of his findings and make recommendations re plans for further procedure along the lines of tests, giving the various items which he considers justifies his plan to fully develop facts on which to base a well-defined method of designing crane bridge girders, verified by test data. The engineer is to work with a committee of three, two members and a representative of the crane companies, as appointed by the chairman, and submit reports from time to time to the general committee."

The committee approved the recommendations of the special committee, and later with the advice and assistance of Bruce Johnston, assistant director of the Fritz Laboratories, Lehigh University, I. E. Madsen was employed to carry out the crane girder design program outlined above. A sub-committee composed of James Farrington and E. H. Windolph was appointed to assist Mr. Madsen. The work was done at Lehigh University under the supervision of Mr. Johnston, and a detailed report of the research work done by Mr. Madsen is given in the 1941 A. I. S. E. Yearbook, page 531. Conclusions from this work are used as basic data in the revised specifications.

Other sub-committees appointed were for the item of gears — I. N. Tull, chairman, R. E. Lewis and James Farrington; and for the item of bearings — H. W. Neblett, chairman, R. N. Thompson and H. W. Ball.

Many of the items contained in the revised specifications present data which are published for the first time. The section on girder design is based on the research and studies made by Mr. Madsen at Lehigh University, and the formulae given recognize all the lateral and horizontal forces that must be resisted and are not modifications of standard column formula or those used in design of bridge structures.

The section on wheel loadings is based on the satisfactory operation of crane wheels and rail sections submitted by many users of these cranes, as well as the recommendation of the builders of cranes and the manufacturers of wheels. Investigation of this subject showed the necessity of using rails designed for heavy loads at low speeds capable of resisting high lateral thrusts.

The proper application of anti-friction bearings to crane wheels is covered by a table of ratings. The deflection of the axles and condition of the runway rails greatly affect the life of anti-friction bearings. These tables have been approved by the bearing manufacturers and have been checked with operating records of satisfactory installations in the mills.

The subject of bridge drives was covered in a symposium held in Pittsburgh when 13 papers were given by authorities on various phases of this subject. These papers are included in the Association Yearbook for 1940. The section of the specifications on this subject is based on information submitted at this symposium plus the experience of many operators.

It is realized that, in setting up specifications for equipment of this nature, some discrepancies, omissions, etc., are unavoidable. The Association invites suggestions and criticism of the specifications, which will be reviewed from the standpoint of the desirability of further revision.

A. I. S. E. STANDARD CRANE SPECIFICATIONS

General

1. Explanation:

These specifications cover heavy duty, mill type, overhead traveling cranes. All cranes for special service such as charging, pit, stripper, ladle, gantry cranes, or ore bridges, etc., shall so far as possible comply with these specifications. The bridge design clauses in these specifications apply only to box girders. For cranes having a span of 100 ft or more, the use of latticed welded girders, or a combination of single web main girder and latticed outrigger girder made of high tensile steel may be considered at the option of the purchaser to obtain a reduction in weight of the bridge.

2. Specifications:

This specification shall be known as the Association of Iron and Steel Engineers' Electric Overhead Traveling Crane Specification. It shall be referred to in all contracts as such and shall form part of such contracts when so stated, whether attached to same or not. Builder's specification shall be known as contractor's specification. These specifications shall take precedence over contractor's specifications and shall be strictly adhered to, and no other specifications or understandings will be considered unless agreed to in writing.

Sheets issued by the purchaser stating sizes, special features, requirements, etc., shall be known as "purchaser's information sheets." Where the requirements of these information sheets differ from specification, the former shall take precedence.

Sheets to be filled in by bidder showing specific data in regard to apparatus he proposes to furnish, shall be known as "contractor's information sheets."

Where contract covers a number of cranes, this specification shall apply to each and every one.

In addition to specifications furnished with proposi-

tion, contractor shall furnish the required number of copies of his specification for the purchaser's file.

3. Note to Bidder:

Bidder shall submit the number of proposals called for on the information sheets, stating therein the price (as specified on questionnaire) for which he, as contractor, will agree to furnish the work as covered by these specifications and information sheets.

Bidder shall furnish with each copy of the proposal:

Complete specifications covering the work proposed to be furnished.

One set of prints showing arrangement and principal details of the work as he proposes to furnish it.

The data called for on questionnaire accompanying and forming part of these specifications.

No alternative propositions will be considered unless accompanied by a proposition in strict accordance with these crane specifications.

The purchaser reserves the right to reject any or all bids.

4. Guarantee:

Contractor shall guarantee that the work furnished under this contract will perform the required functions according to specifications and information sheets, and agree to pay all costs for removing, renewing and installing any part or parts of the work furnished under this contract which may prove defective within one year after placing in regular operation.

5. Patents:

The contractor, in case of work designed or specified by him and even though approved by purchaser, shall and will indemnify, save harmless, and defend the purchaser from and against any and all suits, actions, legal proceedings, claims, demands, damages, costs, expenses, and attorney's fees incident to any infringement, or to any claimed infringement of any patent or patents in any way relating to or connected with the work or any part thereof.

In case a permanent injunction is secured preventing the purchaser from operating the crane as specified, the contractor shall, at his own expense, either:

a. Procure the right for the purchaser to continue using said crane;

b. Modify said crane so as to make it non-infringing — it being understood that such modification must meet with the approval of the purchaser, and must be of such nature as in the judgment of the purchaser will not impair the efficiency or cost of operating such work; or

c. Take back the work, and refund the purchase price for the crane.

6. Changes or Additions:

Purchaser reserves the right to make such changes in specifications or specific information as may be necessary after contract is signed.

Any difference in cost resulting from such changes shall be agreed upon before work is begun on same.

7. Erection (Including assembly, installation, and, if applicable, starting):

Work shall be erected entirely by contractor, or by purchaser, or erected or started under the supervision of contractor's superintendent, whichever is specified on information sheets. So far as is feasible, all work shall be shipped assembled in sections convenient for erection. In any case, contractor shall pay the cost of all fitting or changes necessary for proper functioning of the work.

Where erection is required by contractor or purchaser, all work shall be performed by party specified without recourse to the other party.

Where erection by the contractor is required, he shall be responsible for unloading his equipment, materials, etc., and shall also be responsible for demurrage accrued on cars due to his failure to unload them within the free time.

Where erection under supervision of contractor is required, the contractor shall furnish the purchaser, on terms of payment agreed upon, a competent man to superintend the complete erection of the work. Purchaser will furnish all other required labor and tools. The superintendent of erection shall arrange that the erecting crew will be kept employed to the best advantage.

Where work is to be started under contractor's supervision, the contractor shall furnish the purchaser, on terms of payment agreed upon, a competent man to superintend such starting.

After erection of the work is finished, the contractor shall promptly remove from the premises everything brought in by him which does not pertain to the completed job, leaving the premises clean.

8. Test and Acceptance:

Tests shall be made as specified on information sheets; otherwise, standard factory tests shall be made. In either case the purchaser shall be notified sufficiently in advance, so that he may be represented at all tests.

Acceptance shall be subject to compliance with these specifications and information sheets, to be determined by inspection after delivery, by results of tests above required, and upon the approval of purchaser's representative.

In case of disagreement between contractor and purchaser's representative in regard to the interpretation of any specification or the compliance of the apparatus furnished with the requirements of this specification, the question shall be submitted to the engineering department of the purchasing company for decision.

If the crane does not comply with this specification, the contractor shall be notified to that effect and shall be required to make apparatus meet the specification as quickly as possible. Contractor shall proceed with the work within ten days from date of such notice, and if he fails to do so within the time specified, purchaser reserves the right to make crane comply with the specification at the expense of the contractor.

9. Workmanship, Material, and Inspection:

Workmanship and material shall be first class in every respect, and subject to the inspection of the purchaser's representative at all times.

10. Interchangeability:

All like parts on apparatus furnished or on duplicate apparatus are to be interchangeable.

11. Accessibility:

All working parts shall be arranged for convenient operation, inspection, lubrication, repairs, and ease of replacement.

12. Painting:

All work shall be thoroughly cleaned of all loose mill scale, rust, and foreign matter and then given two shop coats of approved paint. All parts inaccessible after assembling, such as inside of box girders and end carriages, shall be well painted before assembling, except for riveted or welded work, in which surfaces coming in contact are not to be painted. Interior of all anti-friction bearing and gear housings shall be painted with one coat of oil-resisting enamel.

The color and quality of the paint shall be as specified on the information sheets.

13. Safety Devices:

All machinery or equipment furnished under this contract must be equipped by contractor with all proper safety devices to comply with the laws of the state in which it will be installed, the purchaser's safety requirements pertinent thereto and, if stated on the information sheets, any safety requirements peculiar to the purchaser's plant involved.

14. Clearances:

Clearance between any part of the crane, building column, roof chord, or other stationary structure shall be not less than that shown on sketch accompanying the information sheets.

15. Materials and Factor of Safety:

A. Plain cast iron shall not be used for any parts of the crane except for plain counterweights and collector shoes. Alloy cast iron may be used for line shaft bearings, housings, anti-friction bearing cartridges, end caps and drums. No wood or other combustible material shall be used, except for collector staffs and conductor bar bracket supports, unless specifically approved by the purchaser.

B. Ordinary structural steel shall conform with the latest revision of A. S. T. M. Standard Specifications A-7. Low alloy structural steels shall have a composition conducive to weldability, and shall conform with the A. S. T. M. Tentative Specifications for Low-Alloy Structural Steel.

C. The following factors of safety under maximum working load not including impact, based on the yield point of the material used, shall be used in the design of the crane:

All parts subject to reversal of stresses and rough usage including hooks, sheave blocks, bridge and trolley drives, end trucks and complete hoisting mechanism, 4.0.

Trolley frames and structural steel parts with non-reversal of stresses, not including bridge girders, 2.5.

Bridge girders — See bridge girder clause, No. 17.

The factor of safety to be used in the design of welds shall be 4 for bridge girders and 5 for all other parts based on the design ultimate strength of the welds.

D. Wire hoisting ropes shall have a factor of safety of not less than 5 based on the breaking strength as given by the rope manufacturer for the size and grade of rope used.

Structural Design

16. Welded Construction:

A. All welding shall be in accordance with the specifications and standards of the American Welding Society, unless specified otherwise.

B. Welding symbols on drawings shall be in accordance with the latest standard conventions of the American Welding Society.

17. Girders and Bridge Structure (also see Appendix):

A. Crane girders shall be proportioned for the following loads and forces in addition to the dead weight of the complete crane and trolley.

1. *Lifted load:*

The maximum working load shall be as specified on the information sheets. This load is understood to be the load on the crane hooks and does not include the weight of special hooks or lifting beam which are furnished by the manufacturer.

2. *Impact:*

For runways with welded joints and runways with good joints, the impact value shall be taken as follows:

For grab bucket and magnet cranes, the impact value shall be taken as 50 per cent of the maximum working load. For all other cranes the impact value shall be 0.5 per cent of the maximum working load for each foot per minute full load hoisting speed, but in no case to be less than 20 per cent.

3. *Lateral forces:*

These forces result from the acceleration or deceleration in the movement of the crane along the runway, and shall be considered as 20 per cent of the total weight of the crane minus the trucks, plus the maximum working load, multiplied by the ratio of the number of driven wheels to the total number of wheels. The trolley and load are to be located so as to produce maximum moment or shear on the girders. The moment of inertia of the whole girder section about the vertical axis shall be used in calculating the stresses due to lateral forces.

The total lateral load shall be equally divided between both girders.

If the girders and end ties (or the girders and end trucks of 4-wheel cranes) be designed so as to form a rigid frame, lateral end fixity may be considered in the design and the lateral stresses due to lateral forces may be multiplied by a factor of ¾.

4. *Torsional forces:*

The loads and forces creating torsional stress in the girders are:

a. Starting and stopping of the bridge drive motor. The twisting moment shall be considered as the starting torque of the bridge motor at 150 per cent of full load current (crane rating) multiplied by the gear ratio between the motor and the line shaft.

b. Overhanging loads on side of girder, such as footwalk, bridge drive, collector bars, cab, controls, etc. These moments shall be taken as their respective weights multiplied by horizontal distances between the respective centers of gravity and the center of gravity of the girder section.

c. Lateral forces acting eccentric to the horizontal neutral axis of the girder. The twisting moments shall be considered as these forces multiplied by the vertical distance between center line of force and the center of gravity of the girder.

d. The total twisting moment shall be the algebraic sum of the moments resulting from loads in paragraphs 17-A-4-a, 17-A-4-b, and ¾ of the loads in 17-A-4-c. In computing twisting moment, moving loads shall be placed so as to cause the greatest torque on the section.

The maximum torsional unit shear in pounds per square inch shall be computed from the following formula for box girders:

$$V=\frac{M}{2AT}$$

where M = twisting moment in inch pounds

A = area of box section bounded by center line of web and cover plates.

T = thickness of plate considered in box section.

5. *Wind load on outside service cranes:*

a. The wind load shall be taken at 30 pounds per square foot of the projected area.

B. A stress sheet showing the stresses from each of these loads and forces shall be included with the prints submitted by the contractor to the purchaser for approval of design if the purchaser so specifies on the information sheet.

C. 1. For box girders, the combined bending moment stresses shall be taken as the larger of:

a. Sum of maximum stresses due to the dead load, weight of trolley, lifted load and impact.

b. Sum of maximum stresses due to the dead load, weight of trolley, lifted load, and the lateral forces.

2. For box girders, the combined shear shall be taken as the sum of the maximum shears due to the dead load, weight of trolley, lifted load, impact and torsion.

3. Stress due to wind may be neglected if such stress does not increase the total combined stress more than 25 per cent.

D Members subject to reversal of stress shall be proportioned as follows:

Determine the resultant tensile stress and the resultant compressive stress and increase each by 50 per cent of the smaller, then proportion the member so that it will be capable of resisting either increased resultant stress. Connections shall be proportioned for the sum of the stresses.

E. 1. The bridge structure including the end tie and end connection and excluding end trucks and trolley shall be proportioned in accordance with the following (stresses are in pounds per square inch):

	A. S. T. M. A-7-39 structural steel	Low alloy structural steel
2. Minimum ultimate tensile strength	60,000	70,000
3. Minimum yield point	33,000	50,000
4. Unit stress in tension on net section not to exceed	18,000	27,000
5. L/B not to exceed:		
(a) Riveted girders	65	65
(b) Welded girders	60	60
6. Compressive unit stress for top flange of box girders (when W/T does not exceed 40 for carbon structural steel or 33 in the case of low alloy structural steel) shall not exceed	17,000	25,000
or the stress given by the formula	$f_c=\frac{0.673\ E\ \sqrt{I_2J}}{SL}$	
7. When W/T exceeds 40 for carbon structural steel, or 33 in the case of low alloy steel, the compressive stress shall not exceed	$f_c=27{,}200{,}000\left(\frac{T}{W}\right)^2$	
Note: These values are given in Table A. (Appendix)		
8. Compressive unit stress for axially loaded columns and struts shall not exceed	$15{,}000-0.25\left(\frac{L}{R}\right)^2$	$22{,}500-0.57\left(\frac{L}{R}\right)^2$
9. L/R for axially loaded columns and struts shall not exceed	120	120
10. Maximum allowable unit shear (V) in web plates	12,000	18,000
11. Unless vertical stiffeners are used H/T shall not exceed	$\frac{6600}{\sqrt{V}}$	$\frac{6600}{\sqrt{V}}$
Note: These values are given in Table B. (Appendix)		
12. Spacing of vertical stiffeners in inches when required by the foregoing shall not exceed	$\frac{10{,}500\ T}{\sqrt{V}}$	$\frac{10{,}500\ T}{\sqrt{V}}$
Note: These values are given in Table C. (Appendix)		
13. Unless longitudinal stiffeners are used, H/T shall not exceed	$72\ (K+1)\sqrt{\frac{17{,}000}{f_c}}$	$60\ (K+1)\sqrt{\frac{25{,}000}{f_c}}$
This formula applies when K varies from 1.6 to 0.6.		
Note: These values are given in Table D. (Appendix)		

14. If H/T exceeds ratios given by 17-E-13 the webs must be stiffened with adequate and sufficient longitudinal stiffeners. When one longitudinal stiffener is used and placed as specified, (17-E-25), the maximum H/T ratio may be doubled. When two longitudinal stiffeners are used and placed as specified, 17-E-25, the maximum H/T ratio may be tripled.		
15. W/T shall not exceed	$40\sqrt{\frac{17{,}000}{f_c}}$	$33\sqrt{\frac{25{,}000}{f_c}}$

Notation used in formulae:

L = span of crane in inches
B = distance between webs in inches
T = thickness of web or flange in inches
H = clear depth of web — toe to toe of vertical legs of flange angles for riveted construction
— back to back of cover plates for welded construction
V = unit shear in web plates
R = radius of gyration
f_c = maximum compressive stress in member considered
f_t = tension stress acting concurrently with f_c in member
$K = f_t/f_c$
S = vertical section modulus in inches^3
E = modulus of elasticity in 16 per sq. in.
I_z = moment of inertia of whole girder section about vertical axis in inches
J = torsional constant in inches^4 (See appendix for formula)
W = clear width of top flange — distance between inside rivets — riveted girders distance between webs — welded girders

	A. S. T. M. A-141 structural rivet steel	A. S. T. M. A-195 high strength rivet steel
16. Shearing:		
Rivets	13,500	18,000
Pins and turned bolts in reamed or drilled holes	13,500	.....
Unfinished bolts	9,000	.....
17. Bearing:		
Rivets in single shear on:		
Carbon steel	24,000	24,000
High tensile steels	24,000	32,000
Rivets in double shear on:		
Carbon steel	30,000	30,000
High tensile steels	30,000	40,000
Pins and turned bolts in reamed or drilled holes	30,000	.....
Unfinished bolts	16,000	.....

18. The allowable unit weld stresses to use in design are given in Table E in the appendix of these specifications.

19. The bearing stress of parts in contact such as stiffeners and flange plates shall not exceed 27,000 pounds per square inch for milled surfaces and 24,000 pounds per square inch for unfinished surfaces.

20. For stress carrying members, the spaces between intermittent welds shall be not greater than 10 times the thickness of the lighter section joined by the welds for members in compression, nor more than 14 times the thickness of the lighter section for members in tension. The length of any segment of intermittent weld shall be not less than 4 times the weld size with a minimum of 2 inches.

21. Rivets shall be spaced not more than 16 times the thickness of the lighter outside section, or more than 6 inches on centers.

22. The width of the outstanding legs of angles in compression (except where reinforced by plate) shall not exceed $12\ T\sqrt{\frac{17000}{f_c}}$ and shall not exceed 16 T.

23. Unstiffened cover plates shall not extend more than 6 inches nor more than $12\ T\sqrt{\frac{17000}{f_c}}$, where T is the thickness of the thinnest plate, beyond the outer row of rivets connecting them to the angles for riveted construction or the center of the web plates for welded construction

24. The outstanding legs of vertical stiffeners shall not extend more than 16 times the thickness of the leg. The outstanding l_{eg} of horizontal stiffeners shall not exceed $12\ T\sqrt{\frac{17000}{f_c}}$ where f_c is the compression stress in the stiffener.

25. When one longitudinal stiffener is used, on girder webs in bending it shall be placed 21 per cent of the clear depth of the web from the unstiffened compression edge. When two longitudinal stiffeners are used, these distances are 12.5 per cent and 28 per cent of the clear depth of the web from the unstiffened compression edge.

26. The required radii of gyration of horizontal stiffeners are to be computed from the formula in Table F (Appendix) with the appropriate constant selected from the table.

27. The required moment of inertia of intermediate vertical stiffeners shall be computed from $I = 0.00000028\ H^4$ where H is the clear depth of the web.

28. Riveted or welded splices in the webs of plate girders shall be designed for the full strength of the web in both shear and bending.

29. Riveted splices or welded joints of tension members shall have a strength in the net section of the splice plate equal to that of the material spliced. The rivets of the splice shall have a strength 10 per cent in excess of the member.

30. Metal shall not be less than 5/16 in. thick for classification A. S. T. M. A-7-39 steel, or 1/4 in. for high tensile steel unless otherwise specified on information sheets.

31. The depth of the girder shall not be less than 1/18 of the span unless otherwise approved by the purchaser.

32. The total vertical deflection of the girder in inches for the live load plus trolley, and not including impact, shall not exceed 0.0015 inches per inch of span. Girders shall be cambered an amount equal to the dead load deflection plus one-half the live load deflection.

33. Girders shall be proportioned by the moment of inertia of the net section, deducting the rivet holes in the tension area.

34. Full length web diaphragms are required at bridge motor supports and at line shaft bearing pedestals. Such diaphragms shall be rolled section or built up diaphragms extending from web to web of the girder.

35. In addition to the required full length dia-

phragms for box section girders, short diaphragms shall be inserted where required to transmit the trolley wheel load to the web plates and to limit the maximum stress in the trolley rail to 18,000 pounds per square inch based on formula:

$$\text{Stress} = \frac{\text{Wheel load} \times \text{Distance between supports, in inches}}{6 \times \text{Section modulus of rail}}$$

36. Top cover plate shall not be considered as giving support to the rail.

37. All diaphragms must bear against the top coverplate. The thickness of the diaphragm must be sufficient to resist the trolley wheel load in bearing, if the wheel load is considered to be distributed over a distance equal to the width of the rail base plus twice the thickness of the coverplate.

38. Cranes for outdoor use shall be provided with a full length wearing plate under the trolley runway rails if the purchaser so specifies on the information sheets. This plate is to be $\frac{3}{8}$ in. thick, at least as wide as the rail base, and welded in place to the cover plate with $\frac{3}{16}$ in. continuous welds.

39. Stresses for high tensile steels with yield points other than those given in the foregoing shall, in general, be in proportion. The yield point of such steels shall not be taken as more than 75 per cent of the ultimate strength.

40. For box girders, the ratio of depth of box to width of box shall not exceed 3.5.

F. 1. The design of girders at the ends shall be such that the unit shear in the web plates due to the end reaction plus that due to torsion shall not exceed the values given in the tabulation for the various classifications of steel.

2. Girders, other than notched, for 4-wheel cranes shall be rigidly attached to the end carriages. They shall be tied together by vertical end plates. The vertical end plates shall be capable of resisting the torsional moment at the end of the girder, and the rivets or welds on these plates shall be capable of developing this moment. Horizontal plates shall also be provided across the top and ends of the bridge girders. The vertical and horizontal end plates shall have a section modulus equal to that at the end of the bridge girder. Gusset plates shall be provided to assist in keeping the crane square.

3. Notched girders for 4-wheel cranes shall also be provided with horizontal and vertical end plates as above and shall be rigidly attached to the end carriage along the vertical edge of the notch as well as the top edge. Girders with bottom cover plate in line with bottom of end carriage, shall be provided with large gusset plates to connect the bottom cover plate to the bottom of the end carriage.

4. Girders for cranes with equalizer trucks shall have rigid end ties of box construction, the inner plate of which shall be extended down the full depth of the girder before the notch. Top plate of end ties shall be made as wide as possible without interfering with the trolley travel. The section modulus of the box end tie shall be equal to the section modulus of the end of the bridge girder. The rivets or welds between the vertical plates of the box end tie and the bridge girder shall be capable of developing the torsion moments at the end of the bridge girder.

5. When lateral end fixity is used in design, the horizontal moment of inertia and horizontal section modulus of the end tie shall be at least equal to those at the end of the bridge girder. The rivets or welds in the horizontal plates of the end tie shall be capable of developing the lateral end moment.

6. Top and bottom cover plates and angles of girders shall be in one piece throughout the girder length, unless otherwise approved by the purchaser.

7. Box girders shall be so constructed as to eliminate any accumulation of water or oil inside them. If the purchaser so specifies on the information sheets welded girders shall be provided with breathing holes to allow for the expansion or contraction of the air inside due to temperature changes. Special care shall be taken with cranes for outdoor use to eliminate crevices or openings where water may accumulate and cause corrosion.

8. Capacity of each hoist shall be shown in pounds on each side of crane in such a manner as to be easily legible from the floor.

9. An adequate number of fitted bolts for drilled and reamed holes shall be provided to accurately align the girders with the end trucks during field erection. Connection between girders and end trucks shall be as specified on the information sheet.

18. Bridge End Carriages:

A. End carriage shall be of cast steel or structural steel welded, and they shall be made amply strong to prevent breakage under most severe strains resulting from legitimate use of crane.

B. There shall be a heavy safety lug or strap across the bottom of each carriage near the track-wheel and one inch above the top of rail, to prevent excessive drop in case of breakage of track wheel, axle, or carriage. Wheel base shall not be less than 1/6 of the span on long span cranes. On 8-wheel cranes the wheel base is the distance between center lines of the two outside wheels.

C. No part of carriage or track wheel gears shall project below the flange of track wheel.

D. End carriage to be so designed as to permit of easy changing of the wheels.

E. Pads shall be provided for the use of jacks or wedges when changing track wheels.

F. Guards of an approved design which will push forward or off the track any object placed across it, like a person's foot or arm, shall be attached to each end of the carriages. Certain designs require means of supporting guards while bumpers are being removed.

G. If specified on the information sheets, safe means must be provided to get on the bridge of the crane from the crane runway.

H. If specified on the information sheets, all cranes with equalizer trucks shall be provided with steel platforms, on inside of carriages, to give access to all wheels and bearings.

19. Trolley Frames:

A. The trolley shall be welded rolled steel or cast steel construction or a combination of both as specified on the information sheets and the requirements for the bridge end carriages regarding safety lugs, guards, ease of changing wheels and clearances shall also apply to the trolley.

B. Where practicable, all bearing brackets shall be integral with the frames.

C. Roller bearing housing and bearings should be so designed that shaft and bearings can be fitted up complete as a spare.

D. Drum bearings and support for upper sheaves shall be located so as to equalize the load on track wheels as nearly as possible.

E. The trolley shall be of the floored-over type with no openings except for the ropes and magnet cable. Deck plates shall be not less than 5/16 in. thick and shall be provided with toe guards around all openings or edges. The load girt is to be so designed as to carry the load to the side frames.

20. Foot-Walks:

A. Level steel foot-walks made either of anti-slip type floor plate, 3/16 in. thick for indoor cranes, 1/4 in. for outdoor cranes, or expanded metal grating shall be provided on outside of both girders for the full length of the crane, extending to web plate of the girders and fitted around all irregularities, or either (Pennsylvania State Law) to toe angle extending the full length of inside edge of foot walk.

B. Where practicable, walk shall be extended over end carriages and cab, making it continuous around the crane.

C. Foot-walks shall be of sufficient width to give 24 in. clear passage at all points, except between railing and bridge motor where the clearance may be reduced to not less than 12 in. (State Law, 15 in.). The clearance between railing or bridge walk and nearest part of trolley shall not be less than 18 in.

D. Width of trolley walks, if provided, shall not be less than 15 in. The foot-walk along girders should have at least 6 ft 6 in. clearance below roof chords. Foot-walk floor plates shall preferably be welded to supports. If riveted, rivets shall be countersunk on top.

E. Where only practicable to install one such foot-walk it shall be on the side carrying the bridge motor.

F. All exposed sides of foot-walks shall be provided with toe angles which shall extend at least 4 in. above top of walk and to conform to the state code and be not less than 5/16 in. thick.

21. Railings:

A. Railings shall be provided for foot-walks, preferably made of structural steel; shall be of purchaser's standard construction, not less than 42 in. high with toe boards, not less than 4 in. high and to conform to the state code, with intermediate member 21 in. high. Where pipe is allowed welded construction must be used.

B. Railings shall be provided on girder foot-walks, ends of bridge, landing on cab, and on stairs leading to bridge girder from landing on cab as specified.

22. Stairs and Ladders:

A. Steps or ladders shall be provided as specified to give safe and easy access to girders, end carriages, cab, and trolley.

B. Stair treads shall be of material designed to prevent slipping, and shall not be less than 18 in. in width. Where stairs are not constructed with risers, a plate or wire mesh shield shall be attached to the underside, extending the entire length.

C. Where ladders are provided they shall be of steel and constructed with square rungs or have rungs welded to ladder to prevent turning. The rails shall extend 42 in. above landing place at top, for safety in getting on or off the ladder. They shall start on a landing platform.

D. Where slope of stairs would exceed an angle of 55 degrees from the horizontal, ladders shall be used.

E. All foot-walks, railings, ladders, or steps shall be made so as not to interfere with the removal of any part of crane.

23. Operator's Cab:

A. The operator's cab shall be built of structural steel and fireproof material with a clear height with equipment installed of not less than 6 ft 6 in., and shall be made substantial and rigid by proper gusset plates and braces welded or riveted, but such bracing shall not interfere with access to cab or vision of operator. Cab shall also be braced to prevent swinging, and shall be supported by members having all rivets in shear.

B. Enclosed cabs shall have a watertight plate roof which slopes to the rear and be provided with sliding or drop windows on three sides, and with sliding or hinged door. Steel plates for enclosing sides to be not less than 1/8 in. thick. Window sash shall be equipped with clear shatterproof glass installed from the inside so that if it comes out it will fall in the cab. Windows which drop shall be protected from breakage by 1/8 in. sheet steel guard, extending to within 2 in. of the floor, and be provided with handles and stops which will prevent catching a man's hands or toes when operating the windows. Drop windows shall be counterweighted. If control panels are mounted in cab, a steel partition with door shall be provided between the operator and the control panels.

C. Open cabs shall have rear side enclosed with 1/8 in. steel plate. Other three sides shall be enclosed with standard railing 42 in. high, with space between floor and intermediate member enclosed with 1/8 in. steel plate. Where the top rail, if placed 42 in. above the floorline, seriously interferes with the operator's vision, it may be lowered if approved by the purchaser.

D. The floor of the cab, which shall be 1/4 in. thick

steel plate, is to be extended to form a landing platform which is to be provided with hand railing similar in design to that specified for foot-walks. Floor of cage is to be covered with suitable thermal and insulation material ¾ in. thick.

E. Cranes subjected to heat from below must have 3/16 in. sheet steel shield, 6 in. below bottom of floor to insulate floor from heat.

F. If specified, enclosed cabs shall be provided with a combination heating and ventilating unit of size specified on information sheets. Unit to be provided with switch for disconnecting the heating unit when not required.

G. Cab shall be provided with a multiple ringing steel foot gong, not less than 12 in. in diameter, or other suitable warning signal appliance, installed so as to readily be accessible from the cab and located so that parts working loose cannot fall from crane.

H. The above requirements shall be modified if cabs are located other than at the end of the bridge in order to give the operator maximum visibility in all directions at all times. These cabs shall be provided with ladders to the foot-walk and shall be only large enough to house the master controllers, all other control apparatus to be mounted on the foot-walks.

Mechanical Details

24. Drums:

A. Drums shall be made of rolled or cast steel or special high strength cast iron as specified on the information sheets, and to have flanged ends of not less than 1 in. in thickness projecting 2½ in. beyond the body of the drum.

B. They shall have turned grooves of a depth equal to 7/16 of the diameter of the hoisting rope, and a pitch of not less than 1.2 times this diameter. Groove radius shall be 1/32 in. larger than the radius of the rope. Drums shall be so designed that not less than two complete wraps of hoisting rope will remain in the grooves when the hook is at the lowest position, and not require overlapping of rope when hook is in the highest position.

C. The pitch diameter of the drum shall not be less than 30 times the diameter of the hoisting rope used.

D. Drum gear shall be pressed on and keyed to either the periphery or the hub of the drum, or be bolted with body bound bolts to a flange on the drum.

25. Ropes:

A. The hoisting ropes shall be of the grade and type specified on the information sheets.

B. The standard diameters of hoisting rope shall be ½, 5/8, ¾, 7/8, 1, 1⅛, and 1¼ in.

C. Where main conductors are located below the runway rail, a guard shall be provided on the crane to prevent the hoisting ropes from coming in contact with the conductors.

D. Ropes shall be so reeved as to eliminate reverse bends, if possible.

26. Equalizer Bar or Sheave:

Where required, either an equalizer bar or sheave will be acceptable. In either case, it shall be so designed as to be accessible from floor of trolley and be made in such a manner that it can turn or swivel to align itself with the pull on ropes. Equalizer sheaves when used shall have a pitch diameter not less than 18 times the diameter of the rope.

27. Sheaves and Hook Blocks:

A. Sheaves shall be bronze bushed or provided with anti-friction bearings as specified and have finished grooves of a depth at least 1½ times the diameter of the rope.

B. The pitch of all sheaves, except equalizer sheaves, shall be not less than 30 times the diameter of the rope used. They shall be enclosed by guards which fit close to the flanges so as to prevent the ropes from coming out of the grooves.

C. Bottom sheave blocks shall be constructed of rolled, forged or cast steel and be entirely enclosed except for the rope openings. The hook trunnion which shall be separated from the sheave pin, shall be supported by extending the side plates below the sheave housing. Hook shall swivel on ball or other type of anti-friction bearing constructed to exclude dirt and also provided with means of lubrication.

D. Each sheave shall be lubricated by an individual grease line, the fittings to be located so that they will be protected from injury.

E. Where feasible, top sheaves shall be mounted above the trolley floor; otherwise should be accessible by means of a removable plate in the floor.

28. Track Wheels:

A. All track wheels are to be of rolled or forged open hearth steel, .70-.80 per cent carbon, with double flange and treated treads.

B. The flanges of straight tread track wheels shall be not less than 1 in. thick, not including the fillet at tread, nor less than 2 in. greater in diameter than the tread. Flanges of taper tread track wheels shall be not less than 27/32 in. thick, not including the fillet at tread, nor less than 1¾ in. greater in diameter than the tread at the large diameter. (See proposed profile for track wheel, Appendix.)

C. Bridge track wheels used in connection with crane rail section, 171-175, shall have straight treads at least 5 in. wide. All other bridge track wheels shall have treads finished to a taper of 1 in. in 16 in. on the radius and at least 1½ in. wider than the width of the rail head; the specified diameter being at the center of the tread. Taper tread wheels shall be mounted with the large diameter toward the center of the crane. The standard diameters of bridge track wheels shall be 24 in., 27 in., 30 in., and 36 in.; 18 in. and 21 in. wheels may be used if approved by the purchaser.

D. Trolley track wheels shall have straight treads which shall be ½ in. wider than the width of the rail

head, and be on the following standard diameters: 12 in., 15 in., 18 in., 21 in., and 24 in.

E. The maximum load on any track wheel with trolley handling the maximum working load and at the cab end of the crane shall not exceed the values in Table I.

F. In case the size of the bridge runway rail section as specified by purchaser is the deciding factor as to whether 4 or 8 wheels are required on the crane, the purchaser should be notified before complete proposal is prepared so purchaser can give consideration to a heavier section.

29. Rails:

A. All rails shall be first quality and of following sections: A. S. C. E. 60 lb; A. S. C. E. 85 lb; A. R. E. A. 112 lb; A. R. E. A. 131 lb; crane rail section 104-105 lb; crane rail section 170-175 lb.

B. Joints on trolley travel rails shall be made by means of standard joint bars. The ends of rails shall be milled and laid with no openings between the ends. Provision shall be made to prevent creeping of rails on girders by means of stops riveted or welded to cover plate.

C. Unless otherwise specified on the information sheets, rails shall be fastened in place by steel clamps held by through bolts for single web girders. For box girders, rails shall be fastened in place by direct welding to the cover plate, or by suitable clamps, held either by direct welding to the cover plate or by studs welded to the cover plate, or with studs fitted into nuts welded to underside of cover plate before assembly of girder, as specified in the information sheets. Fastenings are to be spaced on not more than 36 in. centers.

D. Rails for trolley travel shall not be less than A. S. C. E. 60 lb section. Rails for bridge travel shall not be less than A. S. C. E. 85 lb section.

E. Wheel loads on rails shall not exceed that given in table in Clause 28. Where the service is severe, it is recommended that 104-105 lb crane rail section be used instead of the A. S. C. E. 85 lb rail, due to its greater thickness of head and web.

30. Bumpers:

A. The crane shall be provided with substantial bumpers of spring or draft gear type, capable of stopping the crane (not including the lifted load) when traveling in either direction at 1/5 of the rated speed with maximum working load, and at an average rate of deceleration not to exceed 3 ft per sec per sec. In addition, bumper springs shall have sufficient energy absorbing capacity to stop the crane when traveling at a speed of at least 40 per cent of full load rated speed.

B. Bridge bumpers shall have a contact surface not less than 5 in. in diameter, be located on the rail center line and be of such length that no part of either crane will be damaged when bumpers of two cranes come together and both are fully compressed. Bumpers shall be rigidly bolted in place, and if bumpers are so located as to require removal when changing trackwheels, means shall be provided on the crane itself, either by hinges or otherwise, for handling the bumper while changing track wheels.

C. Height of bumpers above the top of rail shall be as specified on informaion sheets.

D. Trolley shall be provided with spring type bumpers capable of stopping the trolley (not including the lifted load) when traveling in either direction at 1/3 of the rated speed with maximum working load and at an average rate of deceleration not to exceed 4.7 ft per sec per sec. Where two trolleys are operated on the same bridge, they shall be equipped with spring bumpers on their adjacent ends.

E. The design of all bumpers shall be such that in case of breakage, no part can fall from crane.

TABLE I

Diameter of wheel, in.	Rail section				
	A. S. C. E. 60 lb	A. S. C. E. 85 lb and crane rail section, 104-105 lb	A. R. E. A. 112 lb	A. R. E. A. 131 lb	Crane rail section 171-175 lb
12	28,000*				
15	35,000*				
18	42,000	50,000*			
21	49,000	59,000	66,000*		
24	56,000	67,000	75,000	89,000*	
27		73,000	82,000	95,000	128,000*
30		76,000	86,000	102,000	135,000
36		79,000	90,000	109,000	142,000

*These values will most likely be determined by the stresses in the axle shafts.

31. Bridge Drives:

A. Bridge drive shall consist of one of the of the following arrangements, as specified on information sheets.

(A-1) Back axle motor located at center of bridge. Track wheels driven through gears pressed and keyed on their axles and pinion mounted on end section of line shaft. End sections of line shaft to be connected to line shaft by means of half flexible couplings. All other couplings to be solid type.

(A-2) Plain motor connected by means of flexible couplings to self-contained gear reduction located at center of bridge. Motor to be mounted above the line shaft in order to keep it as close to girder as possible. Balance of arrangement same as (A-1).

(A-3) Plain motor located at center of bridge connected directly to line shaft. Self-contained gear reduction sets located near each end of bridge, connected to wheel axle shafts by means of short shafts with half flexible couplings at each end of these shafts. All other couplings to be solid type, unless high speed shafts of gear reductions have no end play due to type of bearings used, in which case they shall be connected to line shaft by means of half flexible couplings.

(A-4) Plain motor located at center of bridge connected directly to line shaft. Gear reduction sets built in or attached to end trucks, and driving track wheels through gears pressed and keyed on their axles. Line shaft to be connected to gear reduction sets by means of half flexible couplings. All other couplings to be solid.

B. The length of any section of line shaft shall not be more than that specified on the information sheets. End sections to be made as short as practicable, and interchangeable. Line shaft sections for double drive bridge should be duplicates.

C. Line shaft couplings, other than the flexible type are to be made from rolled or forged steel. They are to be of bolted straight flange type, and be provided with a face key and plain bolts, or without face key and with body bound bolts, as specified on information sheets. Couplings shall be located close to bearings and be provided with substantial removable guards at least 12 inches wide. Where half flexible couplings are used, the couplings shall be located close to the bearing on the end truck, and the adjacent line shaft bearing shall not be closer than 4 ft 6 in.

D. Type of bearings to be as specified on information sheets. Line shaft bearings to be spaced not more than 10 ft centers.

E. Supports for motor and reduction gear sets shall be welded structural steel rigidly attached to the crane girder by means of attachments extending the full depth of the girder, and so designed as to produce no lateral bending of the web plates.

F. Bolts for fastening bearing brackets, motors and gear reduction sets shall be easily accessible from top side of foot-walk.

G. Angular deflection of the lineshaft at torque corresponding to 1⅓ times full load motor torque, shall not exceed 0.12 degrees per foot of shaft length.

H. Bridge speed, gear ratio and bridge drive motor size shall be calculated according to methods set forth in Section 43 of these specifications.

32. Shafting:

A. Shafting shall be increased in diameter in ⅛ in. increments, to twice the keyseat depth for a distance equal to the length of the hub fit for pinions, gears, track wheels and drums when tapered keys are used. When parallel faced sunk keys are used, the shaft shall be increased in diameter by 10 per cent to the nearest ⅛ in. increment. A generous fillet or long taper is to be provided at each end of the swell. Shafting need not be increased in size for couplings.

B. The diameter of plain shafting shall be in even ¼ in. sizes.

C. Plain shafting, 6 in. or under in diameter, not having swells or increases, shall be cold or hot rolled or drawn; all above that diameter shall be forged and machined to size.

D. All shafting above 6 in. in diameter, if not hardened, shall be either annealed or normalized and tempered.

E. Sheave pins, pivot pins for equalizer trucks, and axle shafts which are provided with sleeve bearings are to be either case hardened, ground and polished, or ground, polished and nitrided. Surface hardness to be 80 or 90 Shore, depth of case to be 3/16 in. if case hardened.

33. Press Fits and Keys:

Keys shall be provided for all connections subject to torsion. Tapered keys shall bear on sides, top and bottom; parallel faced keys on sides only. All gears, pinions, wheels and couplings shall be pressed or shrunk onto shafts, as specified on the information sheets, in addition to being keyed. All press fits shall be made with a pressure of not less than ten tons per inch of diameter. All keys are to be made of SAE 1040 steel.

34. Bearings:

A. Bearings shall be as specified on the information sheets.

B. Where anti-friction type bearings are specified, the size selected shall be such as to give a minimum life expectancy of 10 years (8,000-65,000 hr) under service conditions for which the crane is intended. See Table G, Appendix, for recommended bearing applications for track wheels. Drawings showing size and type of bearing, details of application, mounting and method of application, shall be submitted by contractor to the bearings manufacturer for approval. Such approval shall be forwarded by contractor to purchaser.

C. Anti-friction line shaft bearings shall have inner races, and preferably be of self-aligning type. Method of securing inner race to shaft to be approved by purchaser.

D. Anti-friction bearings shall be fitted with grease or oil seals of a type approved by purchaser.

E. Housings for anti-friction bearings shall be split, or so designed as to permit of easy removal of the shaft.

F. With track wheel bearings of anti-friction type, one bearing on each track wheel axle shall be of fixed double thrust type; the other bearing shall be arranged to allow for expansion or float of the axle.

G. Sleeve bearings (except those on wheel axles or sealed sleeve type) shall be split horizontally and finished with cast steel caps finished male and female and held by through bolts with locked nuts. They shall be lined with split bushings of hard bronze, or its equal, with flanges on both ends, and held from turning by a heavy lug cast on the top half. Bottom shall be so designed as to permit its removal and renewal without removing shaft.

H. Where sleeve bearings are applied to track wheel axles, the bearing pressure shall not exceed 750 lb per sq in. of projected area. Bearings are to be of such design as to exclude dirt, prevent leakage of oil or grease, eliminate the necessity for frequent oiling or replacement of oil, and meet with approval of purchaser.

I. All bearing caps shall be accurately bored in place with the housings.

35. Bearing Brackets and Housings:

A. Bearing brackets if not integral with frame must be kept in alignment by male and female joints or equally effective method.

B. Where shafting is geared together, the brackets supporting the bearing housings shall be integral and shall be located as close as possible to gear and pinion.

C. Heavy caps shall be provided with eye bolts for lifting.

36. Gearing:

A. Gearing shall be straight spur, herringbone, helical or worm as specified on the information sheets and shall conform to the following specifications or be a product having equal or better strength and wearing qualities.

B. Plain pinions shall be made from forgings. Gears shall, preferably, be made from fabricated steel sections welded or solid wrought steel blanks. Gears and pinions of design and size not suitable for forging, or gears for which suitable wrought steel gear blanks are not obtainable shall be fabricated by welding or cast of steel in accordance with the A. S. T. M. (American Society for Testing Materials) Standard Specifications for Carbon-Steel and Alloy-Steel Castings for Railroads, Designation A87, latest issue, and the carbon and alloy range shall be the same as for the S. A. E. (Society of Automotive Engineers) steels specified in the individual gear specifications. Castings shall be free from blowholes and other injurious defects.

C. All machining operations shall be in accordance with the A. G. M. A. (American Gear Manufacturers Association) standards and recommended practice for the manufacture of industrial gearing.

D. Bores for gears and pinions shall be finish machined or ground to size after heat treatment.

E. Threads of worms and fits on shafts made integral with worms or pinions shall be ground to size after heat treatment.

F. Tolerance limits and allowances for bores and diameters, if not specified, except as to kind of fit, shall be in accordance with the "American Standard" (approved by the American Standards Association) utilizing the class of fit best suited to the product and to the application.

G. Tolerance limits for width of keyways of finished gear, if not otherwise specified, shall be:

+.0000 in.
−.001 in. per in. of width
Viz: −.001 in. up to and including 1 in. width of keyway
−.002 in. from 1 in. to and including 2 in. width of keyway, etc.

H. Keyways shall be in alignment with the axis of the gear, shall be accurately spaced, and shall have parallel straight sides.

I. Profile and detail dimensions of gear teeth shall be in accordance with the A. G. M. A. standards for the system specified.

J. The following tolerance limits apply to gears and pinions made in accordance with Specifications B1 and B2 after the gears and pinions have been heat-treated.

All dimensions are in inches. The outside diameter, used as the basis for determination of undersize, is the original outside diameter as turned, which must not be modified in any manner which will result in a change in tooth contour.

*Tolerances for Specification B*1.

Undersize:

Tolerance limits from the center of gear to the outside diameter shall be:

+.000
−.002×pitch diameter. (The minus tolerance, however, shall not exceed −.080×the working depth of the tooth.)

Taper of tooth bearing:

The tooth surface measured at the pitch line shall be parallel with the axis of the gear within .0001× pitch diameter, per inch of face, but shall not exceed .003×the working depth of the tooth per inch of face.

The total taper of width of face shall not exceed .018×the working depth of the tooth.

*Tolerances for Specification B*2.

Undersize:

Tolerance limits from the center of gear to the outside diameter shall be:

+.000
−.0012×pitch diameter. (The minus tolerance, however, shall not exceed −.048×the working depth of the tooth.)

Taper of tooth bearing:

The tooth surface measured at the pitch line shall be parallel with the axis of the gear within .00060 ×pitch diameter, for each inch of face, but for each inch of face shall not exceed .0018×the working depth of the tooth.

The total taper of width of face shall not exceed .0108×the working depth of the tooth.

Bevel Gears

Tolerance limits specified above are for gears with straight face parallel to the axis. They also apply to bevel gears by using the diameter of the crown for determination of "undersize" and the cone center for the determination of "taper of tooth bearing."

Spiral, Helical and Herringbone Gears

In the case of gears of these types, the taper of the tooth bearing shall be determined from the helix angle.

The total taper of face width shall be for the full face width in the case of spiral and helical gears and for half the full face width in the case of herringbone gears.

K. Detailed Specifications:

*Specification A*1

Carbon steel, fine grain.

S. A. E. 1045

Heat treatment — Normalize gear blank or pinion forging to insure grain refinement.

*Specification A*2

Carbon or alloy steel, fine grain.

S. A. E. 1045

Heat treatment — Normalize or anneal gear blank or pinion forging to insure grain refinement. Rough machine, heat treat as required to obtain 35-40 Shore hardness, or equivalent Brinell hardness 241-285 and then finish gear teeth and other machined surfaces.

*Specification B*1

Carbon steel, fine grain, case hardened.

S. A. E. 1020

Heat treatment — Normalize or anneal to insure grain refinement. Carburize finished gear to obtain depth of case not less than 1/6 nor more than 1/5 of the tooth thickness at the pitch line for gear teeth up to 1.50 diametral pitch. For teeth larger than 1.5 diametral pitch the depth of case shall not be less than 3/16 in. Depth of case for bevel gears shall be based on the tooth thickness at the small end of the teeth. Harden and temper to obtain 85-95 Shore hardness, or equivalent Brinell hardness of 633-712.

*Specification B*2

Alloy steel, fine grain, case hardened.

S. A. E. 2315 or 2320

The use of the different steels specified above is optional with the manufacturer except that pinions integral with the shaft and worms for worm gears shall be made of the higher carbon alloy 2320.

Heat treatment — Normalize or anneal to insure grain refinement. Carburize finished gear to obtain depth of case not less than 1/6 nor more than 1/5 of the tooth thickness at the pitch line for gear teeth up to 1.50 diametral pitch. For teeth larger than 1.5 diametral pitch, the depth of case shall not be less than 3/16 in. Depth of case for bevel gears shall be based on the tooth thickness at the small end of the tooth. Harden and temper to obtain 80-90 Shore hardness, or equivalent Brinell hardness of 595-674.

L. The tooth loads allowed on the teeth of gears and pinions shall not exceed those shown on Charts H and J in the Appendix, the chart giving the lowest load shall govern. All gearing, except worm gearing shall be cut to diametrical pitch with teeth not smaller than 4 pitch.

M. No split gears shall be used, and overhung gears, other than the armature pinion of motors cannot be used without the approval of the purchaser.

N. In order that the speeds of the various motions of the crane may be changed in the future, design shall be such as to allow 15 per cent increase or decrease in the total gear ratio of each drive, if specified on information sheets.

O. All gears and pinions shall have stamped on the rim the S. A. E. number of the steel from which they were made in order to identify them for future replacements.

P. Where worm gear drive is specified for hoist or trolley motions, it shall be designed so as to make self-locking impossible under any condition.

Q. The bronze rim of the worm gear shall be fastened to the hub or center portion of the wheel, so as to prevent it from working loose or slipping. The design of gland or oil seal, where the worm gear is directly mounted on the hoisting drum shall meet the approval of the purchaser.

R. Where possible even gear ratios shall be avoided.

37. Gear Covers:

A. All gears shall be completely covered or guarded by covers, firmly and substantially attached to brackets or other parts of crane, and shall have sufficient clearance to prevent their being struck by any of the enclosed parts, and shall be oil tight.

B. Covers shall be split horizontally and fastened and arranged so that top half can be removed for inspection and repairs without disturbing bottom half.

C. Directly above the mesh line of the teeth, there shall be a hand-hole, with cover held closed by spring hinge.

D. Gear covers should preferably be of sheet steel not less than 3/16 in. thick of welded construction and shall be provided with lugs or other means of handling.

38. Brakes:

A. Hoist Brakes:

1. Each hoisting motor shall be equipped with a magnetic brake of size recommended by the brake manufacturer for the service. On back axle motors, the brake shall be mounted on the commutator end. On motors without back axles, the brake shall be mounted on the outboard end of the motor speed pinion shaft, the end of which shall have a taper fit for the brake wheel of the same dimensions as the armature shaft.

2. On cranes whose capacity is greater than 25 tons, where for reasons of additional protection, or necessity of small hoisting or lower increments, a second brake may be specified by the purchaser. This brake shall be a duplicate of the other brake and be mounted on commutator end of the armature shaft.

B. Trolley Brakes:

Where specified, trolleys with anti-friction bearings shall be provided with either a mechanical drag brake

or an under-sized magnetic brake. The drag brake can be installed either on the trolley motor shaft or directly on the periphery of one of the trolley track wheels. Brake to be of such capacity as to prevent trolley from drifting.

C. Bridge Brakes:

1. Each bridge drive shall be equipped with hydraulic brake or brakes, of sufficient size to stop crane within a distance in feet equal to ten per cent of full load speed in feet per minute, when traveling at full speed with full load. The size of brake furnished shall be the responsibility of the contractor.

2. The stroke of the bridge brake foot pedal shall not be more than 8 in. and lever shall be so designed that it will not interfere with necessary movements of operator's legs or feet while operating the crane.

3. In addition to the hydraulic brakes, all cranes with anti-friction bearings on the bridge drive designed for more than 300 fpm bridge speed, shall be provided with dynamic braking for the bridge motor.

4. If specified, cranes for outdoor service shall be provided with electro-hydraulic brakes on the bridge drive, so arranged that brake will be set when the main disconnecting switch on the foot-walk or in the cab is opened.

5. Brakes should be located as near the center of the squaring shaft as possible.

39. Lubrication:

A. Arrangements shall be made by contractor to permit of the proper lubrication of all parts requiring same, and contractor shall furnish all fittings and equipment necessary for this purpose unless otherwise specified on information sheets. Size and type of fitting to be as specified on the information sheets.

B. Each bearing, except those lubricated by oil in the gear housings, shall have an individual lubricating fitting located at an easily accessible point. Anti-friction bearings shall be provided with vents, equipped with relief fittings, to prevent air pockets. Vents shall be so located as to be visible to the operator when greasing.

40. Bolts, Nuts, and Rivets:

A. Unless otherwise specified, bolts shall be "American Standard Heavy" (as approved by American Standards Association, March, 1933), and nuts shall be "American Standard Heavy" cold pressed hexagon. Bolts shall be provided with locknuts, spring lockwashers, or other means to prevent their being loosened by vibration. Heads of bolts in inaccessible places shall be held from turning by recesses or projecting lugs.

B. No studs, cap screws, or body bound bolts shall be used, except with approval of purchaser. No bolts, except those used in safety flange couplings, shall be located so as to require the use of socket or other special wrench.

C. In all structural work, such as gusset plates, brackets supporting foot-walk and bridge line shaft, bolts are not to be used. Welded or riveted construction shall be used in these locations.

Electrical Details

41. Conductors:

A. Conductors shall be mounted outside of girders and above the deck of the foot-walk and shall be of the rigid type, of low carbon steel for good conductivity and preferably of angles.

B. Where possible, conductors shall be of single length; otherwise, sections of conductors are to be welded together with top surface at weld ground smooth. On cranes where conductors cannot be shipped assembled, splice plates and copper bonds shall be used at each splice, unless otherwise specified.

C. The vertical clearance between conductor contactor shoes and the adjacent conductor supports shall not be less than 1¼ in.

D. On cranes for which magnet cable reels are not specified, provision is to be made on collector supports for two additional bars that could be used for magnet control or other purposes. Hoist and trolley motors are to be provided with four bars for each motor.

E. The main conductors for the crane bridge travel will be furnished and erected by the purchaser. Location and size of these conductors will be furnished by the purchaser.

F. Supports for conductor bars shall be spaced not more than 6 ft for flat bars, and not more than 8 ft for angles, or similar shapes.

42. Collector Shoes:

A. The main bridge collector shoes (2 for positive collector and 2 for negative collector) and also the trolley collector shoes are to be furnished by the contractor. Means for easy access to these shoes for repairs shall be provided.

B. The collector shoes for hoisting motion (and magnet circuit where required) are also to be furnished in duplicate.

C. All collector shoes are to be of type specified on information sheets.

43. Motors:

A. All motors used on the crane to be totally enclosed mill type in accordance with the A. I. S. E. Standards, except housing at armature bearings to be designed for anti-friction type bearings only. A design using motors without back axle is preferred to facilitate easy changing of entire motor. Provisions shall be made by means of lugs or similar construction to line up and hold motors in correct position and eliminate the shear on the motor foot bolts.

B. The size of motors required shall be based on the ½ hour or crane rating as set forth in motor manufacturers ratings, and shall be calculated as follows:

1. The horsepower of the hoist motor shall be based on an overall hoist efficiency of 75-80 per cent.

In determining gear ratio, full load motor speed should be used.

2. The horsepower of the trolley travel motor shall be computed by the following formula:

$$Hp = \frac{k \times W \times V \times 15}{33{,}000}$$

where k = a factor, 4-6 for roller bearing axles.
6-8 for sleeve bearing axles.
W = total weight, trolley plus lifted load, in tons.
V = rated full load speed, fpm.
15 = lb of draw bar pull per ton of weight (Includes gear and bearing friction based on 90 per cent efficiency.)

In determining gear ratio for trolley travel, use full load motor speed.

3. The horsepower of the bridge drive motor shall be computed as follows:

a. With roller bearings:

$$Hp = \frac{3 \times W \times V \times 15}{33{,}000 \times .9}$$

where W = total weight of crane plus lifted load, tons.
V = specified bridge speed, fpm.
15 = lb of draw bar pull per ton of weight (includes gear and bearing friction based on 90 per cent efficiency.)
.9 = a factor introduced by the use of a specified speed of 90 per cent of ultimate bridge speed.

In determining gear ratio for bridge drive, with series wound d-c motors and roller bearing axles, use a motor speed corresponding to a horsepower output of about 1/3 the full load horsepower as determined above.

b. With sleeve bearings:

$$Hp = \frac{2 \times W \times d \times .07 \times V}{33{,}000 \times .9 \times .9 \times D}$$

where W = total weight of crane plus rated load, lb.
d = diameter of axle at journal, in.
V = specified bridge speed, fpm.
D = track wheel diameter, in.
.07 = coefficient of friction of sleeve bearing.

The two factors, .9, are, respectively, the 90 percent speed factor previously mentioned, and the 90 per cent gearing efficiency.

In determining gear ratio for bridge drive with sleeve bearing axles, full load motor speed should be used except with long runways, where travel is long enough to build up excess speed, in which case a motor speed corresponding to a horsepower output lower than full load rating may be desirable.

C. No pinion shall be located on the commutator end of shaft, except with approval of purchaser.

D. When back axle motors are to be furnished by the purchaser, the motor pinion, back shaft, gear and gear case shall be furnished by the contractor.

E. All motors are to be mounted in such a manner as to permit the top half of frame to be swung open on its hinges, or removed.

F. Bearings shall be anti-friction type as specified on information sheets.

G. Hoist motor, unless of the back axle type, shall drive through flexible couplings to the pinion shaft.

H. If couplings are required in the trolley motor drive, they shall be of flexible type.

I. All couplings shall be provided with removable guards, unless entire exterior surface is smooth with no projections of any kind.

44. Controls:

A. Magnetic control shall be used with all bridge and hoist motors, and also with all trolley motors whose crane rating is 20 hp and over. Trolley motors whose crane rating is below 20 hp shall be equipped with manual control.

B. Magnetic control shall be in accordance with the following:

1. Control shall conform to the N. E. M. A. Industrial Control Standards for overhead traveling cranes, Section 1C-14, except as modified by these specifications.

2. Shall be of the full magnetic type with magnetic time element, acceleration, and retardation.

3. Panels shall be Monson slate of ample thickness, mounted on angle supports with bottom of lower panel not less than 6 in. from floor, unless otherwise specified.

4. Dynamic braking contactors shall be spring closed.

5. Where two motors are used on the bridge drive, a duplex panel is to be supplied.

6. Unless otherwise specified, resistors shall be of the cast alloy type, in standard mill type boxes. The resistors shall be of N. E. M. A. classification number as specified on the information sheets.

C. If enclosures are required for control panels, the type of enclosure shall be in accordance with the classifications as listed under Section 1C-2-128 of the N. E. M. A. Industrial Control Standards and as specified on the information sheets.

45. Hoist Limit Switch:

A. Each hoist motor shall be equipped with a standard dynamic braking limit stop, connected directly in the motor circuit, to prevent overtravel in hoisting. This limit stop to have a back-out circuit for lowering hook from hoist master controller. Resistor shall be of the unit type with non-breakable corrosion resisting elements mounted in standard mill type box. The limit stop shall be located so as to be easily accessible for inspection, and, if possible, so it will be operated by the hook block or load beam in such manner that no sheave wheels are necessary.

B. An arrangement using a free swinging weighted beam, hinged at one end and having the other end attached to the limit switch operating cable, or any other simple device not using the hoisting ropes as guides, shall be used to operate the limit switch.

C. If sheaves are used in connection with hoist limit stop, the pitch diameter shall be not less than 18 times the rope diameter.

46. Disconnecting Switches:

A. Each crane shall be provided with a main disconnecting switch of the unfused enclosed type, with provisions made for locking in the open position with three safety locks, and be of sufficient size to meet the Underwriter's requirements. This switch to be located on the foot-walk at a point as near as possible to the main collectors. Where switches of 600 amp capacity or greater are required a two-pole circuit breaker should be used.

B. A second switch or circuit breaker or means for operating the safety switch on the foot-walk shall be provided in the cab, as specified on the information sheets.

C. The following fused double-pole safety switches, all mounted on a small panel in the cab shall be provided.

1. One for crane lights.
2. One for electric heater and ventilating unit.
3. One for outlet box circuit.
4. One for signal lights.
5. One for electrically operated sanders (only if sanders are specified).
6. One for magnet control circuit if magnet cable reel is specified. (If magnet cable reel is not specified, panel shall be arranged for future mounting of safety switch.)

D. The main contactor with overload and no voltage relays for the trolley motor shall also be mounted on this panel, if manual control is used.

47. Wiring:

A. All wire shall be flexible stranded, as per A. S. T. M. specification B8-36, Class C, and I. P. C. E. A. Practice and, except where subject to heat, shall be 600 volt rubber cambric insulation, with flame retarding finish. Where subject to heat from resistors, etc., the wire shall be covered with 600 volt asbestos insulation. Wires shall be installed in rigid metal conduits which shall be continuous to switch boxes or conduit outlets. Flexible steel conduit shall not be used, except where desirable to make connections subject to vibration and where specially approved by purchaser. All wiring shall be in accordance with the regulations of the National Board of Fire Underwriters and the regulations of the state and city where the crane is located.

B. All conduit shall be rigidly attached to the crane to prevent vibration, and shall have suitable bushings at all terminals. Tack welding of conduit to structure is acceptable.

C. Each motor shall be wired independently without common returns.

D. The following standard method of wiring should be used:

1. From main collector shoes, the wiring will extend to the two-pole safety switch or circuit breaker mounted on foot-walk.

2. From this switch, wiring will extend to the main switch or circuit breaker in cab.

3. From this switch, branch circuits will extend to control panels for hoist, bridge, and trolley motions and to the small panel mounting the switches for light, heater, magnet circuit, etc.

E. Three outlets of type approved by the purchaser, for plug receptacles are to be furnished on each crane; one on each walk-way near middle of span and one in cab. This circuit to be connected between the main disconnect switch on the foot-walk and the main conductors.

48. Magnet Cable Reel:

A. On cranes where magnet cable reel, or space for mounting a reel is specified, it must be so located that magnet cable will not foul hoisting cable and, if possible, avoid the use of sheaves or guide rollers for the magnet cable.

B. If the cable reel is of the type driven by gears from hoist shafting, of from extension of the drum shaft,the surface speed of the reel shall be the same as the hook speed, and a loop provided in magnet cable to allow for slack. If specified, this type of reel shall be provided with a clutch for disconnecting when magnet is not in use.

C. Weather protection shall be provided for magnet cable reel and collector rings on cranes for outdoor service.

49. Lighting:

A. All crane cabs shall be provided with adequate lighting. Where magnetic control panels are installed in the cab, lighting is to be provided in that section of the cab with separate control switch on a circuit connected between the main disconnect switch on the foot-walk and the one in the cab.

B. On the bridge structure of each crane, there shall be provided lighting fixtures, as specified on the information sheets. Lighting fixtures are to be mounted on shock absorbers, and so installed that they can be serviced from bridge foot-walks.

50. Signal Lights:

Each crane is to be equipped with signal lights; number, location, color and connections for same to be as specified on the information sheets.

Appendix

The following notes in the appendix are given to amplify some of the design data and to give the background for some of the specification clauses. Much of the girder data is the result of a research investigation carried out at the Lehigh University from 1939-1941. The complete papers for this work are published in the "Iron and Steel Engineer," November, 1941.

The numbers on the following notes refer to the appropriate specification clauses.

17-A-2

The jerk impact measured in the crane tests varied from 9-33 per cent. Theoretically the jerk impact should be $I = \frac{v^2}{57{,}600}\left(\frac{W}{.002\ l+d}\right)$ where v is the hoist speed in ft per min. l is the distance between the drum and hook and d is the deflection of the crane. This formula assumes 20,000 psi stress in the hoist rope but does not take into account any slip of the cable on the drums and sheaves which are hard to evaluate. These latter factors would reduce the impact, and also make an exact analysis impossible.

For the laboratory crane the above formula would give 17 per cent impact and the specification clause would give 15 per cent but specification minimum of 20 per cent would govern.

Impact measured on a skullcracker was 25 per cent of the weight of the magnet and ball. This is less than the specification would require. However, the high speed of the hoist on this type of crane causes a severe constant vibration which will cause wear and tend to loosen the crane. For this reason, the impact factor on this type of crane is kept higher than the value called for by the actual impact.

Cranes with bad runway joints (joints spread or uneven) have large impact stresses. Since the dead weight of the crane and trolley also contribute to the impact stresses, the total amount of impact due to this cause may be very large. The bad joint impact tests in the research investigation were made by running the laboratory crane over wedges under both ends of one bridge girder, thus simulating a bad joint at each end. The drop of the crane was 9/16 in., and the impacts measured when the bridge dropped through this amount were 31 per cent and 51 per cent of the live load, dead load and trolley bending moments. The lower value occurred when the load was hung just off the floor and the higher value occurred when the load was hung high.

When cranes are designed for runway locations where there are bad joints, the joints should either be repaired or the crane should be designed for bad joint impact. It would in general be much more economical to repair the rail joints. If the drop of the laboratory crane had been less than 9/16 in. the impact would have been less and if the drop had been greater, the impact on the laboratory crane would have been greater.

17-A-3

End fixity was found to be present in the lateral load tests. Since such fixity reduces the lateral stresses appreciably, it may be economical to take such fixity into account. However, slip in the end connection will reduce fixity so markedly, that it is necessary to make sure that no slip occurs in the connection.

The tests made in the fabricating shops showed that the whole box girder section acted to resist the lateral loads. The mill tests showed that the maximum lateral force was about 20 per cent of the load on the braked wheels.

17-A-4

Torsional moments are similar to shears in a beam. In addition, the moment arm of the lateral forces acting on a girder will vary if the girder depth is non-uniform.

The formulae by which the torsional shear stresses are computed are theoretically correct for box girders. These formulae were checked by the test program.

The angle of twist in radians per unit length is given by $\theta = \frac{M}{GJ}$

M = twisting moment in inch pounds.

G = shear modulus = 11,500,000 psi for steel.

J is analogous to the polar moment of inertia and for a box section:

$$J = \frac{4A^2}{\sum \frac{S}{T}}$$

where S and T are the length and thickness of each side.

For welded girders the above formulae give results which are very close to measured values. For riveted girders, J must be multiplied by a factor of one-third to allow for the slip which occurs between the rivet and plate. In a riveted box, the length of the sides used in computing J are the distances between the rivets in the plane of the cross-sectipn, since the twist is a function of the amount of material stressed, or the length of the stress path. ("Torsional Properties of Fabricated I-Beam and Box Sections," I. E. Madsen, "*Iron and Steel Engineer*," November, 1941.)

17-C-1

Cranes operating where bad runway joints are present should be also designed for a third stress combination. This combination should take into account the stress condition which occurs when the operator is decelerating while going over a bad runway joint. Since it is unlikely that the crane operator would be using maximum braking force while carrying maximum load, the lateral forces are arbitrarily reduced by a factor of one-half.

The resultant stress combination for which the crane would be designed in such a case would be the sum of the stresses due to the dead load, weight of trolley, lifted load, bad runway impact, and one-half of the lateral forces.

17-D

In box girders, the end connection is probably the only important member subject to reversal of stress. If end fixity is to be counted on in design, this connection must be so designed so that no end slip will occur.

17-E-5

Since the whole section of a box girder resists the lateral loads, the lateral rigidity of a girder is then primarily a function of the distance between the web plates, rather than the width of the cover plate. This

is due to the fact that most of the lateral moment of inertia of a box comes from the web plates.

In addition, the torsional rigidity of a box also increases with the distance between the web plates.

Therefore it seems more logical to use the ratio of the girder length to the distance between the webs as the slenderness ratio of the girder rather than the length-width ratio of the cover plate.

The values given in the specifications are conservative. The riveted girders are allowed a slightly higher ratio than the welded girders to allow for the extra stiffening effect caused by the flange angles and cover-plates of riveted girders.

17-E-6

The girder tests showed that for normal proportions there is no necessity to reduce the compressive stress below the allowable tension stress. A slight reduction has been made in the allowable compressive stresses to allow for the bending stresses in the coverplate directly under the wheel. There is no necessity to use the formula except for girders of unusual proportions. This formula is based on a safety factor of 4.

17-E-7, 17-E-11 and 17-E-12

Tables are computed from these formulae and given in the rear of this Appendix.

17-E-13

This formula is based on the test results, and a factor has been added so that a higher H/T ratio may be used when the girder is not stressed up to its full allowable stress. The factor K has also been added to take into account the variation in the allowable H/T ratio when the web is not stressed equally in tension and compression. This factor is based on the theoretically correct constants, and expresses an equation for the constant which holds in the limits specified. The safety factor used in this formula is 1.83 or the ratio of 33,000 to 18,000.

17-E-14

In order to take advantage of the higher unit stresses, it will be found economical to use longitudinal web stiffeners in many cranes rather than to use a thicker web plate. This is particularly true in alloy steel girders where the use of such stiffeners will result in very appreciable weight savings. Tables are given in the Appendix giving the required sizes of such stiffeners. These tables are computed on the basis that the web is stressed equally in tension and compression. If the tension is greater than the compression the values in the table are conservative. If the tension is appreciably less than the compression, the values would be small.

The stiffener values are also computed on the assumption that the vertical stiffeners are spaced at distances equal to the clear depth of the web. If the vertical stiffeners are spaced closer than this distance, the tabulated values are conservative, and if the vertical stiffeners are spaced further than this, the stiffeners should be slightly larger.

17-E-22 and 23

These specification requirements have been written so that they will also apply safely to the higher unit stresses allowed in alloy steel girders.

17-E-25

The location of horizontal stiffeners is not a constant value. The variation is slight, however, and since the specification requirement for such stiffeners is conservative, the slight variation from the theoretical position, which may occur in some cases, will have little effect.

17-E-27

This formula is empirical and gives conservative values. It is based on a large number of values computed from a more exact formula proposed by E. Chwalla and A. Novak.

17-E-32

This clause for maximum deflection is inserted to keep the deflection of the crane within such limits as will prevent the trolley from creeping. These limits will vary appreciably for roller bearing and sleeve-bearing trolleys.

The tendency for the trolley to creep would depend on the slope of the girder under the trolley. The specification clause should probably then be based on the slope instead of the deflection. The camber which occurs in the crane would modify these factors appreciably, and proper camber in the crane can keep the slope within such limits that there may be very little tendency for the trolley to creep even though the deflection is appreciable.

Since the dead load deflection of the girder can be neutralized by appropriate camber, it should not be considered in computing the allowable deflection. Care should also be taken that more than the specified camber is not put in a bridge girder. This is demonstrated by the fact that most of the trouble with creep in roller bearing trolleys seems to occur when the crane is light with the trolley at the quarter point. The direction of the creep in these cases is away from the span center. The maximum slope which this specification requirement would allow is 0.00226 which occurs at a distance from the end equal to one-fifth the span length, provided that the crane was cambered only for the dead load. Proper live load camber would reduce this slope. Unless the overall friction factor of the trolley is less than 4.52 pounds per ton, there should be no tendency for creep in the trolley due to this factor alone.

Creep may occur rather readily if this slope effect is added to other factors such as hook swing and runways which are out of level. However, when such other factors are present, they are likely to be the dominating factors causing trolley creep, and creep would occur even if there was no deflection in the crane.

17-E-35

This requirement is empirical and will give a rail section which would be strong enough to carry the wheel load if the flange plate were not there. Actually the flange plate may often take most of the wheel load as a beam between the two webs, and the function of the rail in such a case is to merely distribute the load. The actual load taken by each could be computed by equating the deflections of the rail and plate at the same point. Care must be taken that the crane rail and plate are both stiff enough so that excessive dishing of the plate does not occur.

TABLE A

Maximum Clear Widths of Cover Plate

Compressive unit stress in top cover plate, psi	Maximum clear width of cover plate in inches for following thicknesses of compression cover plate												
	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
8,000	14	18	22	25	29	33	36	40	43	47	51	54	58
9,000	14	17	21	24	27	31	34	38	41	45	48	51	55
10,000	13	16	19	23	26	29	32	36	39	42	45	49	52
11,000	12	16	19	22	25	28	31	34	37	40	44	47	50
12,000	12	15	18	21	24	27	30	33	36	39	42	45	48
13,000	11	14	17	20	23	26	29	32	34	37	40	43	46
14,000	11	14	16	19	22	25	27	30	33	36	38	41	44
15,000	11	13	16	19	21	24	27	30	32	35	37	40	43
16,000	10	13	15	18	21	23	26	28	31	33	36	38	41
17,000	10	12	15	17	20	22	25	27	30	32	35	37	40
18,000	10	12	15	17	20	22	24	27	29	32	34	36	39
19,000	9	12	14	17	19	21	24	26	28	31	33	36	38
20,000	9	12	14	16	18	21	23	25	28	30	32	35	37
21,000	9	11	13	16	18	20	22	25	27	29	31	34	36
22,000	9	11	13	15	17	20	22	24	26	28	31	33	35
23,000	8	11	13	15	17	19	21	23	25	28	30	32	34
24,000	8	11	13	15	17	19	21	23	25	28	30	32	34
25,000	8	10	12	14	16	18	21	23	25	27	29	31	33

Above computed from $f_c = 27{,}200{,}000 \left(\frac{T}{W}\right)^2$

TABLE B

Limiting Clear Depth of Girder for Omission of Vertical Stiffeners

Thickness of web plate, in.	Clear depth of web in inches for the following values of unit shear in web, psi																	
	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000
1/4	52	37	30	26	23	21	20	18	17	17	16	15	15	14	13	13	12	12
5/16	65	46	37	32	29	27	25	23	22	21	20	18	18	17	17	16	16	15
3/8	78	55	45	39	35	32	30	28	26	25	24	22	22	21	20	19	19	18
7/16	91	64	53	45	41	37	34	32	30	29	27	26	25	24	24	23	22	21
1/2	105	74	60	52	47	43	39	37	35	33	31	30	29	28	27	26	25	24
9/16	117	83	68	58	52	48	44	41	39	37	35	33	32	31	30	29	28	27
5/8	131	92	75	65	58	53	49	46	43	41	39	37	36	35	34	33	32	31
11/16	144	102	83	71	64	59	54	51	48	45	43	41	40	38	37	36	35	34
3/4	157	111	90	78	70	64	59	55	52	49	47	45	43	42	40	39	38	37
13/16	170	120	98	84	76	69	64	60	56	54	51	48	47	45	44	42	41	40
7/8	183	129	105	91	82	75	69	65	61	58	55	52	50	48	47	45	44	43
15/16	196	139	113	98	87	80	74	69	65	62	59	56	54	52	50	49	47	46
1	209	148	120	104	93	85	79	74	69	66	63	60	58	56	54	52	51	49

Above computed from $\frac{H}{T} = \frac{6600}{\sqrt{V}}$

TABLE C

Maximum Spacing of Vertical Stiffeners on Girders without Horizontal Stiffeners

Thickness of web plate, in.	Stiffener spacing in inches, for the following values of unit shear in web, psi																	
	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000
1/4	83	58	48	41	37	34	31	29	28	26	25	24	23	22	21	21	20	19
5/16	104	73	60	52	46	42	39	37	34	33	31	30	29	27	27	26	25	24
3/8	125	88	72	62	56	51	47	44	41	39	37	36	34	33	32	31	30	29
7/16		102	84	72	65	59	55	51	48	46	44	42	40	38	37	36	35	34
1/2		117	96	83	74	68	63	59	55	52	50	48	46	44	43	41	40	39
9/16			108	93	83	76	71	66	62	59	56	54	52	49	48	46	45	44
5/8			120	104	93	85	78	73	69	66	62	60	57	55	54	52	50	49
11/16				114	102	93	86	81	74	72	69	66	63	61	59	57	55	54
3/4					111	102	94	88	83	79	75	72	69	66	64	62	60	58
13/16						110	102	95	90	85	81	77	74	71	69	67	65	63
7/8							110	103	97	92	87	83	80	77	75	73	70	68
15/16								110	104	98	94	89	86	82	80	78	75	73
1									111	105	100	95	92	88	86	83	80	78

Above computed from $d = \frac{10500\ T}{\sqrt{V}}$

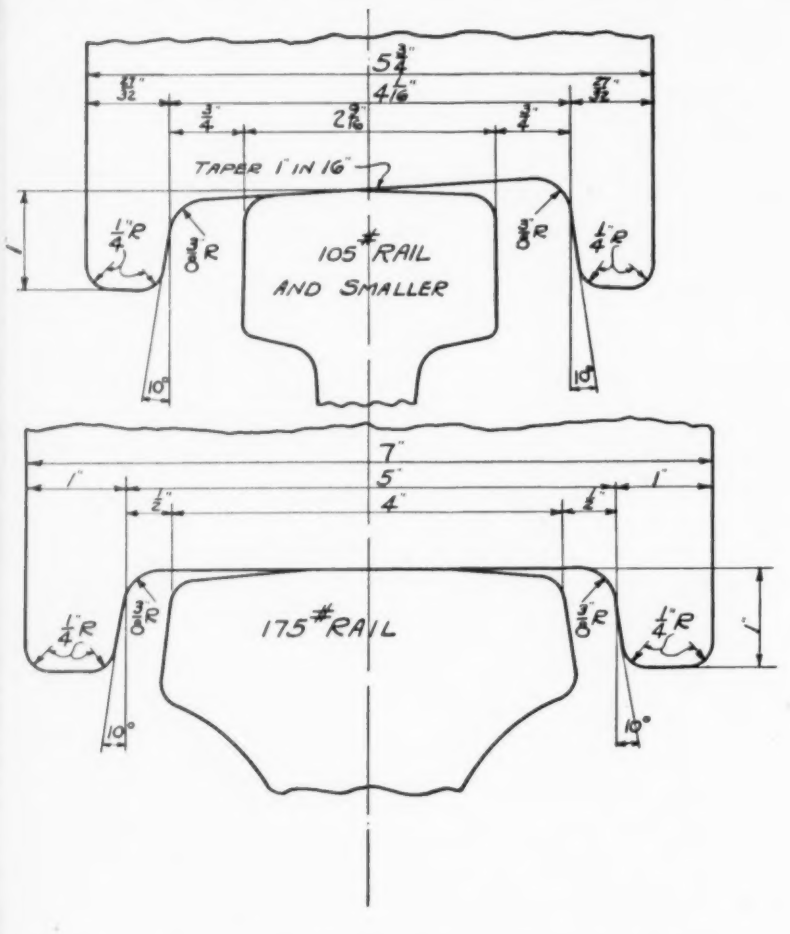
TABLE D

Maximum Allowable H/T Ratios on Girders without Horizontal Stiffeners

Compressive unit stress at toe of flange angles, psi	Maximum H/T ratios on girder webs with no horizontal stiffeners for following K values										
	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
8,000	168	178	189	200	210	220	231	241	252	262	273
9,000	158	168	178	188	198	208	218	228	238	248	258
10,000	151	160	169	179	188	198	208	216	226	235	244
11,000	143	152	161	170	179	188	197	206	215	224	233
12,000	138	146	155	163	172	181	189	198	206	215	224
13,000	132	140	148	157	165	173	182	190	198	206	215
14,000	127	135	143	151	159	167	175	183	191	199	207
15,000	122	130	137	145	153	161	168	176	184	191	199
16,000	118	126	133	141	148	155	163	170	178	185	192
17,000	115	122	130	137	144	151	158	165	173	180	187
18,000	112	119	126	133	140	147	154	161	168	175	182
19,000	109	116	122	129	136	143	150	156	163	170	177
20,000	106	113	120	126	133	140	146	153	160	166	173
21,000	103	110	116	123	129	136	142	148	155	161	168
22,000	101	108	114	121	127	133	140	146	152	158	165
23,000	99	105	111	118	124	130	137	143	149	155	161
24,000	97	103	109	115	121	127	133	139	145	151	157
25,000	95	101	107	113	119	125	131	137	143	149	155

Above computed from $\frac{H}{T} = 72\ (K+1)\sqrt{\frac{17000}{f_c}}$

or $\frac{H}{T} = 60\ (K+1)\sqrt{\frac{25000}{f_c}}$ $\qquad K = \frac{f_t}{f}$



Proposed profiles for crane track wheels.

TABLE E

Design Stresses in Fillet Welds

Length of leg of fillet weld, in. ("weld size")	Working strength, lb per linear inch of one fillet	
	Factor of safety based on design ultimate strength	
	4	5
1/8	940	750
3/16	1410	1120
1/4	1870	1500
5/16	2340	1870
3/8	2810	2250
7/16	3280	2620
1/2	3750	3000
9/16	4220	3370
5/8	4690	3710
11/16	5160	4120
3/4	5630	4500
13/16	6090	4870
7/8	6560	5250
15/16	7030	5620
1	7500	6000
1 1/8	8440	6750
1 1/4	9370	7500

TABLE F

Values of Stiffener Coefficient

	Values of C, for the following values of web thickness, T, in inches					
	5/16	3/8	7/16	1/2	9/16	5/8
Riveted steel — one stiffener	1.07	1.37	1.67	1.99	2.29	2.64
Riveted steel — two stiffeners	0.59	0.73	0.87	1.02	1.17	1.33
Welded steel — one stiffener	1.14	1.46	1.79	2.13	2.48	2.84
Welded steel — two stiffeners	0.65	0.80	0.95	1.11	1.27	1.44

$$\gamma_1 = C\left(\frac{H}{T}\right)^2 f_c \ (10)^{-9}$$

γ_1 = required radius of gyration of one stiffener about face of web, in inches
H = clear depth of web
T = thickness of web
f_c = maximum compression stress in clear depth of web
C = appropriate value selected from above table

For more exact values, the designer is referred to: "Theory of Elastic Stability Applied to Structural Design" by L. S. Moisseiff and F. Lienhard, Proc. ASCE, Jan., 1940. The above values were taken from this paper.

TABLE G

TABULATION OF BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

LOADS GIVEN BELOW ARE BOX LOADS

FOR WHEEL LOADS DOUBLE THIS AMOUNT

LOAD PER BOX in POUNDS	MAKE OF BEARING	FITZ. BORE	CLASS No. 1 — 65,000 HRS. MIN. LIFE — COIL STORAGE, STOCK YARD, SLAG HANDLING, SKULL CRACKER, MIXING AND SHIPPING — 1 TO 30 R.P.M.	CLASS No. 1 — 31 TO 60 R.P.M.	CLASS No. 1 — 61 TO 100 R.P.M.	CLASS No. 2 — 50,000 HRS. MIN. LIFE — LADLE CRANE, CHARGING MACHINE, SOAKING PIT — 1 TO 30 R.P.M.	CLASS No. 2 — 31 TO 60 R.P.M.	CLASS No. 2 — 61 TO 100 R.P.M.	CLASS No. 3 — 40,000 HRS. MIN. LIFE — ROLL SHOP, STRIPPER — 1 TO 30 R.P.M.	CLASS No. 3 — 31 TO 60 R.P.M.	CLASS No. 3 — 61 TO 100 R.P.M.	CLASS No. 4 — 35,000 HRS. MIN. LIFE — MILL SERVICE CRANE, MOULD YARD, COLD STRIP MILL — 1 TO 30 R.P.M.	CLASS No. 4 — 31 TO 60 R.P.M.	61 TO 100 R.P.M.	1 TO 30
1,000	HYATT	1.5748"	R-3108-TS	R-3108-TS	R-3108-TS	R-3108-TS	R-3108-TS	R-3108-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	
	ROLLWAY	1.5748"	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	
	S.K.F.	1.5748"	21308	21308	21308	21308	21308	21308	21308	21308	21308	21308	21308	21308	21308	
	TIMKEN	1½"	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	10180-10284	
	TYSON							Note: Bearing not Available at Present								
	NORMA-HOFFMANN	1.5748"	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	
3,000	HYATT	1.7717"	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	
	ROLLWAY	1.7717"	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	
	S.K.F.	1.7717"	21309	21309	22309	21309	21309	22309	21309	21309	21309	21309	21309	21309	21309	
	TIMKEN	1¾"	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	35178-35326	
	TYSON							Note: Bearing not Available at Present								
	NORMA-HOFFMANN	1.7717"	E-165-L	E-345-L	E-345-L	E-165-L	E-345-L	E-345-L	E-165-L	E-165-L	E-345-L	E-165-L	E-165-L	E-345-L	E-165-L	
5,000	HYATT	2.1654"	A-5311-TS	A-5311-TS	A-5311-TS	A-5311-TS	A-5311-TS	A-5311-TS	A-5211-TS	A-5211-TS	A-5311-TS	A-5211-TS	A-5211-TS	A-5311-TS	A-5211-TS	
	ROLLWAY	2.1654"	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	
	S.K.F.	2.1654"	21311	22311	22311	21311	22311	22311	21311	22311	22311	21311	22311	21311	22311	
	TIMKEN	2¾"	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	
	TYSON							Note: Bearing not Available at Present								
	NORMA-HOFFMANN	2.1654"	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	E-355-L	
7,000	HYATT	2.5591"	A-5313-TS	A-5313-TS	A-5313-TS	A-5213-TS	A-5313-TS	A-5313-TS	A-5213-TS	A-5213-TS	A-5313-TS	A-5213-TS	A-5213-TS	A-5313-TS	A-5213-TS	
	ROLLWAY	2.5591"	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	
	S.K.F.	2.5591"	21313	22313	22313	21313	22313	22313	21313	22313	22313	21313	22313	21313	22313	
	TIMKEN	2⅞"	479-472-A	479-472-A	560-552A	479-472-A	479-472-A	560-552-A	479-472-A	479-472A	560-552A	3984-3920	3984-3920	479-472A	3984-3	
	TYSON	2⅞"	3984-3920	3984-3920	494N-493	3984-3920	3984-3920	479-472	3984-3920	3984-3920	3984-3920	3984-3920	3984-3920	3984-3920	3984-3	
	NORMA-HOFFMANN	2.5591"	E-305-L	E-305-L	E-305-L	E-105-L	E-305-L	E-305-L	E-165-L	E-305-L	E-305-L	E-105-L	E-305-L	E-305-L	E-10	
9,000	HYATT	2.9528	A-5315-TS	A-5315-TS	A-5215-TS	A-5215-TS	A-5315-TS	A-5315-TS	A-5215-TS	A-5215-TS	A-5315-TS	A-5215-TS	A-5215-TS	A-5315-TS	A-5215-TS	
	ROLLWAY	2.9528	D-315	D-315	D-315	D-315	D-315	D-315	D-315	D-315	D-315	D-315	D-315	D-315	D-3	
	S.K.F.	2.9528	21315	22315	22315	21315	22315	22315	21315	22315	22315	21315	21315	22315	21315	
	TIMKEN	3"	47680-47620	47680-47620	575-572	47680-47620	47680-47620	575-572	47680-47620	47680-47620	575-572	495A-493	495A-493	47680-47620	495A-4	
	TYSON	3"	495A-493	575-572	575-572	495A-493	495A-493	575-572	495A-493	495A-493	575-572	495-A-493	495A-493	575-572	495A-4	
	NORMA-HOFFMANN	2.9528	E-375-L	E-375-L	E-375-L	E-375-L	E-375-L	E-375-L	E-375-L	E-375-L	E-375-L	E-375-L	E-375-L	E-375-L	E-17	
10,000	HYATT	3.1496"	A-5316-TS	A-5316-TS	A-5316-TS	A-5216-TS	A-5316-TS	A-5316-TS	A-5216-TS	A-5216-TS	A-5316-TS	A-5216-TS	A-5216-TS	A-5316-TS	A-5216-TS	
	ROLLWAY	3.1496"	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	
	S.K.F.	3.1496"	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	
	TIMKEN	3⅛"	580-572	580-572	595-592-A	580-572	580-572	595-592-A	580-572	580-572	595-592A	495-493	495-493	580-572	495-4	
	TYSON	3⅛"	495-493	580-572	595-592-A	495-493	580-572	580-572	495-493	580-572	580-572	495-493	495-493	580-572	495-4	
	NORMA-HOFFMANN	3.1496"	E-380-L	E-380-L	E-380-L	E-380-L	E-380-L	E-380-L	E-380-L	E-380-L	E-380-L	E-380-L	E-380-L	E-380-L	E-38	
13,000	HYATT	3.5433"	A-5218-TS	A-5218-TS	A-5318-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218	
	ROLLWAY	3.5433"	D-218-46	D-218-46	D-218-46	D-218-46	D-218-46	D-218-46	D-218-46	D-218-46	D-218-46	D-218-46	D-218-46	D-218-46	D-218	
	S.K.F.	3.5433"	22318	22318	22318	22318	22318	22318	22318	22318	22318	22318	22318	22318	22318	
	TIMKEN	3½"	593-592-A	593-592-A	679-672	593-592-A	593-592-A	679-672	593-592-A	593-592A	679-672	593-592A	593-592A	593-592A	593-5	
	TYSON	3½"	593-592-A	593-592-A	679-672	593-592-A	593-592-A	679-672	593-592-A	593-592A	679-672	593-592-A	593-592-A	593-592-A	593-6	
	NORMA-HOFFMANN	3.5433"	E-390-L	E-390-L	E-390-L	E-390-L	E-390-L	E-390-L	E-390-L	E-390-L	E-390-L	E-190-L	E-390-L	E-390-L	E-19	
15,000	HYATT	3.7402"	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	
	ROLLWAY	3.7402"	D-319	D-319	D-319	D-319	D-319	D-319	D-319	D-319	D-319	D-319	D-319	D-319	D-3	
	S.K.F.	3.7402"	22319	22319	22319	22319	22319	22319	22319	22319	22319	22319	22319	22319	22	
	TIMKEN	3¾"	683-672	683-672	777-772	683-672	683-672	777-772	683-672	683-672	777-772	594-592A	594-592A	683-672	594-5	
	TYSON	3¾"	683-672	683-672	776-772	594-592-A	683-672	776-772	594-592-A	683-672	776-772	594-592-A	683-672	683-672	594-5	
	NORMA-HOFFMANN	3.7402"	E 395-L	E-395-L	E-395-L	E-395-L	E-395-L	E-395-L	E-395-L	E-395-L	E-395-L	E-395-L	E-395-L	E 395-L	E-19	
18,000	HYATT	3.9370"	A-5320-TS	A-5320-TS	A-5320-TS	A-5220-TS	A-5320-TS	A-5320-TS	A-5220-TS	A-5220-TS	A-5320-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-522	
	ROLLWAY	3.9370"	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-32	
	S.K.F.	3.9370"	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	2232	
	TIMKEN	4"	780-772	780-772	861-854	780-772	780-772	861-854	780-772	780-772	861-854	687-672	687-672	780-772	687-6	
	TYSON	4"	687-672	780-772	780-772	687-672	780-772	780-772	687-672	780-772	780-772	52400-52618	780-772	780-772	52400-5	
	NORMA-HOFFMANN	3.9370"	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-4	
20,000	HYATT	3.9370"	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	
	ROLLWAY	3.9370"	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5220	C-5 5	
	S.K.F.	3.9370"	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	2232	
	TIMKEN	3 15/16"	71425-71750 A	71425-7175 A	936-932 A	71425-71750 A	71425-71750 A	936-932 A	71425-71750 A	71425-71750 A	936-932 A	71425-71750 A	71425-7175 A	71425-71750 A	64433-		
	TYSON	4"	71425-71750	71425-7175D	936-932	71425-71750	71425-71750 A	936-932	71425-71750	71425-71750	936-932	71425-71750	71425-71750	71425-71750	71425-		
	NORMA-HOFFMANN	3.9370"	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-400-L	E-40		
24,000	HYATT	4.3307"	A-5322-TS	A-5322-TS	A-5322-TS	A-5222-TS	A-5322-TS	A-5322-TS	A-5222-TS	A-5222-TS	A-5322-TS	A-5222-TS	A-5222-TS	A-5222-TS	A 522		
	ROLLWAY	4.3307"	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5222	C-5 5		
	S.K.F.	4.3307"	22322	22322	22322	22322	22322	22322	22322	22322	22322	22322	22322	22322	22 32		
	TIMKEN	4⅛"	938-932	938-932	938-932	938-932	938-932	938-932	938-932	938-932	938-932	938-932	938-932	71450-71750	71450-		
	TYSON	4⅛"	71450-71750	938-932	938-932	71450-71750	938-932	938-932	71450-71750	71450-71750	938-932	71450-71750	71450-71750	71450-71750	71450-		
	NORMA-HOFFMANN	4.3307"	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-4		
30,000	HYATT	4.7244	A-5324-TS	A-5324-TS	A-5324-TS	A-5224-TS	A-5324-TS	A-5324-TS	A-5224-TS	A-5224-TS	A-5324-TS	A-5224-TS	A-5224-TS	A-5324-TS	A-5224-TS		
	ROLLWAY	4.7244	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224	C-5 5224		
	S.K.F.	4.7244	22324	22324	22324	22324	22324	22324	22324	22324	22324	22324	22324	22324	22324		
	TIMKEN	5"	96500-96925	96500-96925	EE 163050-163100	96500-96925	96500-96925	EE 163050-163100	96500-96925	96500-96926	EE 163050-163100	67388-67320	67388-67320	96500-96926	67388-		
	TYSON	5"	895N-892	895N-892	896N-892	74600-74850	895N-892	896N-892	96500-96925	790N-792	895N-892	790N-792	895N-892	895N-892	790N-		
	NORMA-HOFFMANN	4.7244	E-420-L	E-420-L	E-420-L	E-420-L	E-420-L	E-420-L	E-420-L	E-420-L	E-420-L	E-420-L	E-420-L	E-420-L	E-4		
40,000	HYATT	5.2992	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS		
	ROLLWAY	5.5118"	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5228	C-5 5		
	S.K.F.	5 5118"	22328	22328	22328	22328	22328	22328	22328	22328	22328	22328	22328	22328	222		
	TIMKEN	5⅝"	99575-99100	99575-99100	EE 157057-157105	99575-99100	99575-99100	EE 157057-157105	99575-99100	99575-99100	EE 157057-157105	99575-99100	99575-99100	99575-99100	EE M7057-157105	82670-	
	TYSON	5⅝"	99575-99100	85405BN-158/157N	158576N-158/157N	99575-99100	99575-99100	158405BN-158/157N	99575-99100	99575-99100	158405BN-158/157	99575-99100	99575-99100	99575-99100	85405BN-158/157N	99575-	
	NORMA-HOFFMANN	5.5118"	E 440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-44	
50,000	HYATT	6.6929"	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS		
	ROLLWAY	6.2992"	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5232	C-5 5		
	S.K.F.	6.2992"	22332	22332	22332	22332	22332	22332	22332	22332	22332	22332	22332	22332	223		
	TIMKEN	6½"	94649-94113	94649-94113	EE 159065-159132	94649-94113	94649-94113	EE 159065-159132	94649-94113	94649-94113	EE 159065-159132	94649-94113	94649-94113	94649-94113	EE 159065-159132	94649	
	TYSON	6½"	94649-94113	58650N-158/157N	47006EN-47015N	94649-94113	158650N-158/157N	47006EN-47015N	94649-94113	158650N-158/157N	158650N-158/157N	94649-94113	94649-94113	94649-94113	158650N-158/157N	94649-	
	NORMA-HOFFMANN	-	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)		
60,000	HYATT	7.4803"	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS		
	ROLLWAY	7.4803"	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238	C-5 5238		
	S.K.F.	7.4803"	22338	22338	22338	22338	22338	22338	22338	22338	22338	22338	22338	22338	223		
	TIMKEN	8½ 8⅝"	HM 222015-222/216 A	HM 222015-222/216 A	EE 420751-421437 A	HM 222015-222/216 A	HM 222015-222/216 A	EE 420751-421437 A	HM 222015-222/216 A	HM 222015-222/216 A	EE 420751-421437 A	HM 222015-222/216 A	HM 222015-222/216 A	HM 222015-222/216 A	EE 420751-421437	93750-	
	TYSON	7½	222070N-222/216	222070N-222/216	420751N-421437	222070N-222/216	222070N-222/216	420751N-421437	93750-93125	222070N-222/216	222070N-222/216	93750-93125	222070N-222/216	222070N-222/216	222070N-222/216	93750-	
	NORMA-HOFFMANN	-	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)	RMS 22½-L (1¾" Axles)		
70,000	HYATT	7.8740"	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS		
	ROLLWAY	7.8740"	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5240	C-5 5		
	S.K.F.	7.8740"	23140	23140	22340	22340	22340	22340	22340	22340	22340	22340	22340	22340	223		
	TIMKEN	8"	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	420801-	
	TYSON	8"	420801-421437	430800N-431575	430800N-431575	420801-421437 (Axle) RMS 22-L (8" Axle)	420801-421437 (Axle) RMS 22-L (8" Axle)	430800N-431575	420801-421437 (Axle) RMS 22-L (8" Axle)	420801-421437 (Axle) RMS 22-L (8" Axle)	430800N-431575	420801-421437 (Axle) RMS 22-L (8" Axle)	420801-421437 (Axle) RMS 22-L (8" Axle)	420801-421437 (Axle) RMS 22-L (8" Axle)	420801-421437 (Axle) RMS 22-L (8" Axle)	99600-	
	NORMA-HOFFMANN	-															
80,000	HYATT							Note: Bearing not Available at Present									
	ROLLWAY	8.6614"	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5244	C-5 5		
	S.K.F.	8.6614"	23144	23144	22344	23144	23144	22344	23144	23144	22344	23144	23144	23144	231		
	TIMKEN	9"	EE 430900-431575	EE 430900-431575	EE 700091-700167	EE 430900-431575	EE 430900-431575	EE 700091-700167	EE 430900-431575	EE 430900-431575	EE 700091-700167	EE 430900-431575	EE 430900-431575	EE 430900-431575	EE 430900-431575	EE 430900	
	TYSON	9"	430900-431575	923090N-923175	923090N-923175	430900-431575 (Axle) RMS 27-L (9" Axle)	430900-431575	923090N-923175	430900-431575 (Axle) RMS 27-L (9" Axle)	430900-431575	923090N-923175	430900-431575 (Axle) RMS 27-L (9" Axle)	430900-431575	430900-431575	430900-431575	430900	
	NORMA-HOFFMANN																
90,000	HYATT							Note: Bearing not Available at Present									
	ROLLWAY	9.4488"	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5 5148	C-5		
	S.K.F.	9.4488"	23948	23948	22348	23948	23948	22348	23948	23948	23248	23948	23948	23948	231		
	TIMKEN	9½"	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095	
	TYSON	9½"	430950N-431575	923095-923175	923095-923175	430950N-431575	923095-923175	923095-923175	430950N-431575	923095-923175	923095-923175	430950N-431575	923095-923175	923095-923175	923095-923175	430950N	
	NORMA-HOFFMANN	10"				RMS 28-L							RMS 28-L			RMS	
100,000	HYATT							Note: Bearing not Available at Present									
	ROLLWAY	9.4488"	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5 5248	C-5		
	S.K.F.	9.4488"	23248	23948	23948 (10K'd)	23948	23948	23948 (10K'd)	23948	23948	23948	23948	23948	23948	231		
	TIMKEN	9½"	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095	
	TYSON	9½"	923095-923175	295950-295193	295950-295193	923095-923175	295950-295193	295950-295193	430950N-431575	923095-923175	295950-295193	430950N-431575 (Axle) RMS 28-L	923095-923175	295950-295193	923095-923175	430950N	
	NORMA-HOFFMANN	10"														RMS	

MINIMUM LIFE OF HOURS BASED ON 10% FAILURES

	CLASS No. 5 25,000 HRS. MIN. LIFE MACHINE SHOP			CLASS No. 6 8,000 HRS. MIN. LIFE POWER HOUSE MOTOR ROOM INDUSTRIAL CRANES		
61 TO 100 R.P.M.	1 TO 30 R.P.M.	31 TO 60 R.P.M.	61 TO 100 R.P.M.	1 TO 30 R.P.M.	31 TO 60 R.P.M.	61 TO 100 R.P.M.
A-5208-T5	A-5208-T5	A-5208-T5	A-5208-T5	A-5208-T5	A-5208-T5	A-5208-T5
D-208	D-208	D-208	D-208	D-208	D-208	D-208
21308	21308	21308	21308	21308	21308	21308
16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284
E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L
A-5209-T5	A-5209-T5	A-5209-T5	A-5209-T5	A-5209-T5	A-5209-T5	A-5209-T5
D-309	D-309	D-309	D-309	D-309	D-309	D-309
21309	21309	21309	21309	21309	21309	21309
35178-35226	35178-35226	35178-35226	35178-35226	35178-35226	35178-35226	35178-35226
E-145-L	E-145-L	E-145-L	E-145-L	E-145-L	E-145-L	E-145-L
A-5211-T5	A-5211-T5	A-5211-T5	A-5211-T5	A-5211-T5	A-5211-T5	A-5211-T5
D-311	D-311	D-311	D-311	D-311	D-311	D-311
22311	21311	21311	22311	21311	21311	21311
28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622
E-355-L	E-155-L	E-355-L	E-355-L	E-155-L	E-155-L	E-155-L
A-5213-T5	A-5213-T5	A-5213-T5	A-5213-T5	A-5213-T5	A-5213-T5	A-5213-T5
D-313	D-313	D-313	D-313	D-313	D-313	D-313
22313	21313	21313	22313	21313	21313	21313
479-472A	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920
3984-3920	396A-394A	3984-3920	3984-3920	396A-394A	396A-394A	396A-394A
E-368-L	E-165-L	E-165-L	E-365-L	E-165-L	E-165-L	E-165-L
A-5215-T5	A-5215-T5	A-5215-T5	A-5215-T5	A-5215-T5	A-5215-T5	A-5215-T5
D-315	D-315	D-315	D-315	D-315	D-315	D-315
22315	21315	21315	22315	21315	21315	21315
47680-47620	495A-493	495A-493	495A-493	495A-493	495A-493	495A-493
575-572	495A-493	495A-493	495A-493	495A-493	495A-493	495A-493
E-375-L	E-175-L	E-375-L	E-375-L	E-175-L	E-175-L	E-175-L
A-5216-T5	A-5216-T5	A-5216-T5	A-5216-T5	A-5216-T5	A-5216-T5	A-5216-T5
D-316	D-316	D-316	D-316	D-316	D-316	D-316
22316	22316	22316	22316	22216	22216	22316
580-572	495-493	495-493	580-572	495-493	495-493	495-493
580-572	495-493	495-493	580-572	495-493	495-493	495-493
E-380-L	E-380-L	E-380-L	E-380-L	E-180-L	E-180-L	E-180-L
A-5218-T5	A-5218-T5	A-5218-T5	A-5218-T5	A-5218-T5	A-5218-T5	A-5218-T5
D-218-45	D-218-45	D-218-45	D-218-45	D-218-45	D-218-45	D-218-45
22318	22218	22318	22318	22218	22218	22218
593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A
593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A
E-390-L	E-190-L	E-390-L	E-390-L	E-190-L	E-190-L	E-190-L
A-5219-T5	A-5219-T5	A-5219-T5	A-5219-T5	A-5219-T5	A-5219-T5	A-5219-T5
D-319	D-319	D-319	D-319	D-319	D-319	D-319
22319	22219	22319	22319	22219	22219	22219
683-672	594-592A	594-592A	683-672	594-592A	594-592A	594-592A
683-672	594-592A	594-592A	683-672	594-592A	594-592A	594-592A
E-395-L	E-195-L	E-395-L	E-395-L	E-195-L	E-195-L	E-195-L
A-5220-T5	A-5220-T5	A-5220-T5	A-5220-T5	A-5220-T5	A-5220-T5	A-5220-T5
D-320	D-320	D-320	D-320	D-320	D-320	D-320
22320	22220	22320	22320	22220	22220	22220
780-772	687-672	687-672	780-772	687-672	687-672	687-672
780-772	52400-52618	687-672	780-772	52400-52618	52400-52618	52400-52618
E-400-L	E-200-L	E-400-L	E-400-L	E-200-L	E-200-L	E-200-L
A-5320-T5	A-5320-T5	A-5320-T5	A-5320-T5	A-5220-T5	A-5220-T5	A-5220-T5
CS-5220	CS-5220	CS-5220	CS-5220	CS-5220	CS-5220	CS-5220
22320	22320	22320	22320	22220	22220	22320
71425-71750A	64433-64700A	64433-64700A	71425-71750A	64433-64700A	64433-64700A	64433-64700A
71425-71750	71425-71750	71425-71750	71425-71750	71425-71750	71425-71750	71425-71750
E-400-L	E-400-L	E-400-L	E-400-L	E-200-L	E-200-L	E-400-L
A-5222-T5	A-5222-T5	A-5222-T5	A-5222-T5	A-5222-T5	A-5222-T5	A-5222-T5
CS-5222	CS-5222	CS-5222	CS-5222	CS-5222	CS-5222	CS-5222
22322	22322	22322	22322	22222	22222	22322
938-932	71450-71750	71450-71750	71450-71750	64450-64700	64450-64700	71450-71750
938-932	71450-71750	71450-71750	71450-71750	71450-71750	71450-71750	71450-71750
E-410-L	E-410-L	E-410-L	E-410-L	E-210-L	E-210-L	E-410-L
A-5224-T5	A-5224-T5	A-5224-T5	A-5224-T5	A-5224-T5	A-5224-T5	A-5224-T5
CS-5224	CS-5224	CS-5224	CS-5224	CS-5224	CS-5224	CS-5224
22324	22324	22324	22324	22224	22224	22324
96500-96926	67388-67320	67388-67320	96500-96926	67388-67320	67388-67320	67388-67320
898N-892	796N-792	898N-892	898N-892	796N-792	796N-792	796N-792
E-420-L	E-420-L	E-420-L	E-420-L	E-220-L-A	E-220-L-A	E-420-L
A-5232-T5	A-5232-T5	A-5232-T5	A-5232-T5	A-5232-T5	A-5232-T5	A-5232-T5
CS-5228	CS-5228	CS-5228	CS-5228	CS-5228	CS-5228	CS-5228
22328	22228	22328	22328	22228	22228	22328
EE M78671-M7105	82670-82950	82670-82950	99670-99100	82570-82950	82570-82950	82570-82950
M78671N-M78107N	99675-99100	99675-99100	99675-99100	81578-81962	81578-81962	99675-99100
E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-220-L-A	E-440-L-A	E-440-L-A
A-5234-T5	A-5234-T5	A-5234-T5	A-5234-T5	A-5234-T5	A-5234-T5	A-5234-T5
CS-5232	CS-5232	CS-5232	CS-5232	CS-5232	CS-5232	CS-5232
22332	22232	22332	22332	22232	22232	22232
EE 21906S-21912Z	94649-94113	94649-94113	EE 21906S-21912Z	94649-94113	94649-94113	94649-94113
M78650N-M78121N	94649-94113	94649-94113	M78650N-M78121N	89650N-89105N	89650N-89105N	94649-94113
(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L
A-5238-T5	A-5238-T5	A-5238-T5	A-5238-T5	A-5238-T5	A-5238-T5	A-5238-T5
CS-5236	CS-5238	CS-5238	CS-5238	CS-5238	CS-5238	CS-5238
22336	22236	22336	22336	22236	22236	22236
EE 420701-421437	93750-93125A	93750-93125A	EE 420701-421437	93750-93125A	93750-93125A	93750-93125A
2220704N-222126	93750-93125	2220704N-222126	2220704N-222126	93750-93125	93750-93125	93750-93125
(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L
A-5240-T5	A-5240-T5	A-5240-T5	A-5240-T5	A-5240-T5	A-5240-T5	A-5240-T5
CS-5240	CS-5240	CS-5240	CS-5240	CS-5240	CS-5240	CS-5240
22340	22240	22340	22340	22240	22240	22240
EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	93800-93125	93800-93125	93800-93125
420801-421437	93800-93125	420801-421437	420801-421437	93800-93125	93800-93125	93800-93125
(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L
CS-5244	CS-5244	CS-5244	CS-5244	CS-5244	CS-5244	CS-5244
23344	23144	23144	22344	23144	23144	23144
EE 430900-431575	EE 430900-431575	EE 430900-431575	EE 430900-431575	96900-96140	96900-96140	96900-96140
430900-431575	430900-431575	430900-431575	430900-431575	85150N-8520	96900-96140	96900-96140
	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L	(5" Rods) RM5-28-L
CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148	CS-5148
23148	23148	23148	23148	23148	23148	23148
EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 125095-125145	EE 125095-125145	EE 125095-125145
923095-923175	430950N-431575	430950N-431575	923095-923175	125095-125145	430950N-431575	430950N-431575
	RM5-28-L	RM5-28-L		RM5-28-L	RM5-28-L	RM5-28-L
CS-5248	CS-5248	CS-5248	CS-5248	CS-5248	CS-5248	CS-5248
23148	23148	23148	23148	23148	23148	23148
EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 125095-125145	EE 125095-125145	EE 125095-125145
923950-924593	430950N-431575	430950N-431575	923095-923175	430950N-431575	430950N-431575	430950N-431575
	RM5-28-L			RM5-28-L	RM5-28-L	RM5-28-L

530641

TABLE H

Strength Loads

Allowable loads on 14½° standard and 20° stub tooth spur gears and pinions of 1 diametral pitch, per inch of face. Figures are based on strength of tooth. (All loads in pounds)

Tooth loads

Factor fy	Material and design stress: S.A.E. 1020 steel, case hardened to 80 Shore scleroscope (595 Brinell) 11,000 psi	S.A.E. 1045 steel, normalized. Used for gears only 13,000 psi	S.A.E. 1045 steel, normalized and heat treat to 35 Shore scleroscope (241 Brinell) 16,000 psi	S.A.E. 2315 steel, case hardened to 80 Shore scleroscope (595 Brinell) 22,000 psi
.07	770	910	1120	1540
.08	880	1040	1280	1760
.09	990	1170	1440	1980
.10	1100	1300	1600	2200
.110	1210	1430	1760	2420
.120	1320	1560	1920	2640
.130	1430	1690	2080	2860
.140	1540	1820	2240	3080
.150	1650	1950	2400	3300
.160	1760	2080	2560	3520
.170	1870	2210	2720	3740
.180	1980	2340	2880	3960
.190	2090	2470	3040	4180
.200	2200	2600	3200	4400
.210	2310	2730	3360	4620
.220	2420	2860	3520	4840
.230	2530	2990	3680	5060
.240	2640	3120	3840	5280
.250	2750	3250	4000	5500
.260	2860	3380	4160	5720
.270	2970	3510	4320	5940
.280	3080	3640	4480	6160
.290	3190	3770	4640	6380
.300	3300	3900	4800	6600
.310	3410	4030	4960	6820
.320	3520	4160	5120	7040
.330	3630	4290	5280	7260
.340	3740	4420	5440	7480
.350	3850	4550	5600	7700
.360	3960	4680	5760	7920
.370	4070	4810	5920	8140
.380	4180	4940	6080	8360
.390	4290	5070	6240	8580
.400	4400	5200	6400	8800
.410	4510	5330	6560	9020
.420	4620	5460	6720	9240
.430	4730	5590	6880	9460
.440	4840	5720	7140	9680
.450	4950	5850	7200	9900
.460	5060	5980	7360	10120

For pitches other than 1 diametral pitch divide by the diametral pitch.
For helical or herringbone gears multiply loads by

$$1+\left(\frac{\text{pitch line velocity}}{100}\times .09\right)$$

Values of factor fy
Top figures are for 20° stub teeth
Bottom figures are for 14½° standard teeth

No. of teeth	Pitch line velocity in feet per minute: 100	200	300	400	500	600	700	800	900	1000
12	.267 .180	.233 .158	.207 .140	.187 .126	.170 .115	.156 .105	.144 .097	.133 .090	.124 .084	.117 .079
13	.277 .189	.242 .165	.215 .147	.194 .132	.176 .120	.162 .110	.149 .102	.138 .094	.129 .088	.121 .083
14	.291 .194	.254 .170	.226 .151	.203 .136	.185 .123	.170 .113	.156 .104	.145 .097	.136 .090	.127 .085
15	.299 .202	.262 .177	.233 .157	.209 .142	.190 .129	.150 .118	.161 .109	.150 .101	.140 .094	.131 .089
16	.309 .207	.271 .182	.241 .161	.217 .145	.197 .132	.181 .121	.167 .112	.155 .104	.144 .097	.135 .091
17	.315 .213	.275 .188	.245 .167	.220 .151	.200 .137	.184 .126	.169 .116	.157 .108	.147 .100	.138 .094
18	.323 .224	.283 .196	.251 .174	.226 .157	.206 .142	.189 .131	.174 .120	.162 .112	.151 .104	.141 .098
19	.331 .234	.290 .205	.257 .182	.232 .164	.211 .149	.193 .137	.178 .126	.165 .117	.154 .109	.145 .102
20	.336 .243	.294 .212	.261 .189	.235 .170	.214 .154	.196 .142	.181 .131	.168 .121	.157 .113	.147 .106
21	.342 .248	.299 .217	.266 .193	.239 .173	.218 .158	.200 .145	.184 .133	.171 .124	.160 .116	.150 .108
23	.351 .253	.308 .221	.273 .197	.246 .177	.224 .161	.205 .148	.169 .136	.176 .126	.164 .118	.154 .111
25	.359 .261	.314 .229	.279 .203	.251 .183	.229 .166	.210 .153	.193 .141	.180 .131	.168 .122	.157 .114
27	.366 .269	.320 .236	.285 .209	.256 .188	.233 .171	.214 .157	.197 .145	.183 .135	.171 .126	.160 .118
30	.375 .274	.328 .240	.291 .213	.262 .192	.238 .175	.219 .160	.202 .148	.187 .137	.175 .128	.164 .120
33	.381 .279	.334 .244	.297 .217	.267 .195	.243 .177	.223 .163	.205 .150	.191 .139	.178 .130	.167 .122
36	.387 .285	.338 .249	.301 .221	.271 .199	.246 .181	.226 .166	.208 .153	.193 .142	.180 .133	.169 .125
40	.393 .291	.344 .255	.305 .227	.275 .204	.250 .185	.229 .170	.211 .157	.196 .146	.183 .136	.172 .128
45	.399 .298	.349 .261	.310 .232	.279 .209	.254 .190	.233 .174	.215 .161	.199 .149	.186 .139	.174 .131
50	.406 .302	.356 .264	.316 .235	.284 .211	.259 .192	.237 .176	.219 .162	.203 .151	.190 .141	.178 .132
55	.411 .304	.359 .266	.319 .237	.287 .213	.261 .194	.240 .178	.221 .164	.205 .152	.192 .142	.180 .133
60	.415 .307	.363 .269	.323 .239	.290 .215	.264 .195	.242 .179	.223 .165	.207 .153	.194 .143	.182 .134
75	.425 .312	.372 .273	.331 .243	.298 .218	.271 .199	.248 .182	.229 .168	.213 .156	.198 .146	.186 .137
100	.434 .318	.380 .278	.338 .247	.304 .223	.276 .202	.253 .186	.234 .171	.217 .159	.202 .148	.190 .139
150	.444 .323	.389 .283	.346 .251	.311 .226	.283 .206	.259 .189	.239 .174	.222 .162	.207 .151	.194 .141
300	.458 .328	.401 .287	.356 .255	.320 .230	.291 .209	.267 .192	.246 .177	.229 .164	.214 .153	.200 .144
Rack	.471 .334	.413 .293	.367 .260	.330 .234	.300 .213	.275 .195	.254 .180	.236 .167	.220 .156	.206 .146

TABLE J

Wear Loads

Allowable loads on 14½° standard and 20° stub tooth spur gears and pinions of 1 diametral pitch, in pounds per inch of face, based on wear.

No. of teeth	Shore scleroscope hardness of 35 (240 Brinell) — Pitch line velocity in feet per minute										Shore scleroscope hardness of 80 (600 Brinell) — Pitch line velocity in feet per minute									
	100	200	300	400	500	600	700	800	900	1000	100	200	300	400	500	600	700	800	900	1000
12	2140 1710	1870 1500	1660 1330	1500 1200	1360 1090	1260 1000	1150 920	1070 860	1000 800	940 750	5060 4050	4440 3550	3960 3160	3550 2840	3220 2580	2960 2370	2740 2190	2540 2030	2360 1890	2220 1780
13	2310 1850	2020 1620	1800 1440	1620 1300	1470 1180	1350 1080	1250 1000	1160 930	1070 860	1010 810	5490 4390	4810 3850	4280 3420	3850 3080	3500 2800	3210 2750	2960 2370	2750 2200	2560 2050	2400 1920
14	2490 2000	2180 1750	1930 1550	1740 1400	1580 1270	1440 1160	1350 1080	1250 1000	1160 930	1080 870	5900 4720	5180 4140	4610 3690	4140 3310	3760 3010	3450 2760	3190 2550	2960 2370	2760 2210	2590 2070
15	2670 2140	2330 1870	2070 1660	1870 1500	1700 1360	1560 1250	1430 1150	1330 1070	1250 1000	1170 940	6320 5060	5550 4440	4940 3950	4440 3550	4040 3230	3700 2960	3410 2730	3180 2540	2960 2370	2780 2220
16	2850 2280	2500 2000	2220 1780	2000 1600	1810 1450	1660 1330	1530 1230	1420 1140	1320 1060	1250 1000	6750 5400	5920 4740	5260 4210	4740 3790	4300 3440	3960 3160	3640 2910	3390 2710	3160 2530	2960 2370
17	3020 2420	2650 2120	2360 1890	2120 1700	1920 1540	1760 1410	1630 1310	1510 1210	1410 1130	1320 1060	7180 5740	6290 5030	5600 4480	5020 4020	4580 3660	4190 3350	3880 3100	3600 2880	3350 2680	3150 2520
18	3210 2570	2810 2250	2500 2000	2250 1800	2040 1630	1880 1500	1720 1380	1600 1280	1500 1200	1400 1120	7600 6080	6660 5330	5920 4740	5320 4260	4850 3880	4440 3550	4100 3280	3800 3040	3550 2840	3320 2660
19	3390 2710	2960 2370	2640 2110	2370 1900	2150 1720	1970 1580	1820 1460	1690 1350	1580 1260	1480 1180	8010 6410	7020 5620	6250 5000	5620 4500	5110 4090	4690 3750	4320 3460	4010 3210	3750 3000	3510 2810
20	3560 2850	3120 2500	2770 2220	2500 2000	2260 1810	2070 1660	1920 1540	1790 1430	1660 1330	1560 1250	8440 6750	7400 5920	6590 5270	5920 4740	5390 4310	4940 3950	4550 3640	4220 3380	3950 3160	3700 2960
21	3750 3000	3280 2620	2910 2330	2620 2100	2370 1900	2190 1750	2010 1610	1870 1500	1750 1400	1640 1310	8860 7090	7780 6220	6910 5530	6210 4970	5650 4520	5190 4150	4790 3830	4440 3550	4150 3320	3890 3110
23	4100 3280	3590 2870	3190 2550	2870 2300	2610 2090	2390 1910	2210 1770	2050 1640	1910 1530	1790 1430	9700 7760	8510 6810	7580 6060	6810 5450	6190 4950	5680 4540	5240 4190	4860 3890	4540 3630	4250 3400
25	4460 3570	3900 3120	3460 2770	3120 2500	2840 2270	2600 2080	2400 1920	2220 1780	2070 1660	1950 1560	10550 8440	9250 7400	8220 6580	7400 5920	6720 5380	6160 4930	5690 4550	5290 4230	4940 3950	4620 3700
27	4810 3850	4210 3370	3750 3000	3380 2700	3060 2450	2810 2250	2590 2070	2400 1920	2250 1800	2100 1680	11390 9110	10000 8000	8890 7110	7990 6390	7260 5810	6660 5330	6150 4920	5710 4570	5320 4260	5000 4000
30	5350 4280	4680 3740	4160 3330	3750 3000	3400 2720	3120 2500	2880 2300	2680 2140	2500 2000	2340 1870	12660 10130	11100 8880	9880 7900	8880 7100	8080 6460	7400 5920	6840 5470	6340 5070	5920 4740	5550 4440
33	5890 4710	5150 4120	4580 3660	4120 3300	3750 3000	3440 2750	3160 2530	2940 2350	2750 2200	2580 2060										
36	6410 5130	5610 4490	5000 4000	4500 3600	4090 3270	3750 3000	3450 2760	3210 2570	3000 2400	2810 2250										
40	7120 5700	6240 4990	5550 4440	5000 4000	4540 3630	4160 3330	3840 3070	3560 2850	3320 2660	3120 2500										
45	8020 6420	7020 5620	6240 4990	5620 4500	5100 4080	4680 3740	4320 3460	4010 3210	3750 3000	3510 2810										
50	8910 7130	7800 6240	6940 5550	6250 5000	5680 4540	5200 4160	4800 3840	4460 3570	4160 3330	3900 3120										
55	9800 7840	8580 6860	7620 6100	6880 5500	6240 4990	5720 4580	5280 4220	4900 3920	4580 3660	4290 3430										
60	10700 8560	9360 7490	8320 6660	7500 6000	6810 5450	6240 4990	5750 4600	5350 4280	5000 4000	4680 3740										

For helical and herringbone gears multiply figures by 1.21
For pitches other than 1 diametral pitch divide by the diametral pitch
Upper figures are for gear ratio of 5 to 1
Lower figures are for gear ratio of 2 to 1
Interpolate for intermediate ratios and hardness

A. I. S. E. CRANE SPECIFICATIONS

INFORMATION SHEETS

.....Company

.....Works

Located at.....

Specification No..... Dated.....

For

.....TON ELECTRIC OVERHEAD TRAVELING CRANE

(This information to be furnished bidder by purchaser)

The following specific information, together with the A. I. S. E. Specifications for heavy duty mill type cranes, dated....., shall form the complete specifications of number as noted above.

Contractor shall furnish.....

.....

.....

as covered by these specifications.

Crane to be delivered F.O.B.....

Crane to be erected by.....

Complete wiring of crane, including furnishing of switches, panels, lighting fixtures, etc., shall be done by

.....

All motors, controls for motors, hoist limit switches and magnetic brakes shall be furnished by.....

..... (If furnished by purchaser, they will be delivered F.O.B. contractor's plant for erection by the contractor on the crane.)

Number of sets of prints, etc., to be furnished:

1. Specifications.....
2. Bills of material.....
3. General arrangements, and
   - (a) Details of such parts as are subject to wear and will require replacement.....
   - (b) All details.....

Cranes covered by these specifications will be used for.....

.....

.....

DETAILS

(Clause numbers mentioned in Items 14, 22, 23, and 51 refer to A. I. S. E. Specifications for Heavy Duty Mill Type Cranes.)

1. Building clearance, location of cage and bridge runway conductors are shown on accompanying drawing No.....

2. Maximum working loads:

Main hoist..... 1st trolley.....lb

2nd trolley.....lb

Auxiliary hoist..... .....lb

3. Speeds (with maximum working loads):

Main hoist .....fpm

Auxiliary hoist.....fpm

Bridge travel.....fpm

Trolley travel.....fpm

4. Distance top of runway rail to floor line..... ft.....in.

5. Total lift of hook above the floor line (exclusive of travel required to operate the limit switch):

Main hoist..... ft.....in.

Auxiliary hoist..... ft.....in.

6. Travel of hook below the floor line:

Main hoist..... ft.....in.

Auxiliary hoist..... ft.....in.

7. Span of crane, centerline to centerline of bridge runway rails..... ft.....in.

8. Minimum distance, centerline of main hook to centerline of bridge runway rail:

Cab end..... ft.....in.

End opposite cab..... ft.....in.

9. Minimum distance, centerline of main hook to centerline of auxiliary hook..... ft.....in.

10. Crane runway rails to be section No.....

11. Trolley rails to be of section No.....

12. Trolley rails shall be fastened to girders by.....

13. Height of centerline of bumpers above top of crane runway rails.....

14. Is repair structure over trolley to be furnished?.....

15. Are track sanders to be furnished?.....

16. Bridge drive shall be in accordance with paragraph.....of clause No. 31.

17. Sections of line shaft shall not be longer than ..... ft ..... in.
18. Type of line shaft couplings to be .....
19. Kind of fit for gears, pinions, wheels, couplings, etc. .....

20. Bearings:

Anti-friction bearings are to be furnished .....

Sleeve bearings are to be furnished .....

21. Type of anti-friction bearings to be furnished on motors .....
22. Lubricating fittings are to be .....
23. Type of gearing to be furnished .....
24. Gears shall be in accordance with specification ..... of clause No. 36.
25. Pinions shall be in accordance with specification ..... of clause No. 36.
26. Hoisting drums to be made of .....
27. Number of hoist brakes required .....
28. Is trolley drag brake to be furnished? .....
29. Is safety handle on crane hook to be furnished? .....
30. Is safety latch on crane hook to be furnished? .....
31. Is lock to prevent hook from swiveling to be furnished? .....
32. Color and quality of paint:

First coat .....

Second coat .....

33. Power for operating crane to be .....
34. Type of cab .....
35. Is heat shield under cab to be furnished? .....
36. Size or capacity of heating and ventilating unit for cab to be furnished .....

37. Location of control panels .....
38. N. E. M. A. classification number of resistors .....
39. Location of resistance .....
40. Is enclosure for magnetic control panels and resistances required? .....

41. N. E. M. A. classification of type of enclosure to be furnished .....
42. Relative position of master control switches to be in accordance with attached drawing No. .....

43. Is magnet reel to be furnished? .....
44. Type of magnet reel .....
45. Extra flexible magnet cable to be furnished by .....
46. Magnet control to be installed by .....
47. Magnet control to be furnished by .....
48. Is space to be provided on trolley for future mounting of magnet cable reel? .....
49. Size and number of lighting fixtures to be provided on bridge girders:

50. Collector shoes are to be made in accordance with accompanying drawing No. .....
51. Signal lights as follows shall be furnished .....

52. Method of attaching girders to end carriages at field erection shall be .....

53. In accordance with clause 46-B, concerning safety switches, there shall be installed in the cab .....

SPECIAL FEATURES

A. I. S. E. CRANE SPECIFICATIONS

.....Company
.....Works

Located at.....
Specification No..... Dated.....

For

.....TON ELECTRIC OVERHEAD TRAVELING CRANE

The data called for below are to be furnished by the bidder, and in case the bidder becomes the contractor, the data shall form part of the contract covering the work.
(If motors are furnished by purchaser, the contractor shall specify the hp and rpm of the motors he recommends.)

1. Name of bidder.....
2. Date of proposition.....
3. Is it the bidder's intention, if awarded the contract, to comply fully and in all respects with purchaser's specifications covering the work? If not, bidder shall state exceptions in detail.....
4. Time in which contractor will agree to deliver or complete all work covered by these specifications.....
5. Lump sum price for which contractor will agree to.....
.....ton electric overhead traveling crane as covered by these specifications.

(Where the specifications require consideration be given to the use of high tensile steels for crane girders, a separate price shall be quoted for crane with high tensile steel girders. The saving in weight due to the use of these high tensile steels shall also be given.)

6. Amount included in above lump sum price for:

Motors..... $.....
Control..... $.....
Magnetic brakes..... $.....
Hoist limit switches..... $.....

7. Number of cranes furnished.....
8. Total weight of crane including electrical equipment.....
9. Total weight of trolley including electrical equipment.....
10. Weight of each bridge girder as assembled ready for erection.....
11. Weight of each end carriage as assembled ready for erection.....

12. Hoists:	Main hoist	Auxiliary hoist
Speed, feet per minute		
A. With maximum working load		
B. With empty hook		
Ropes, size		
Number of rope parts supporting the load		
Diameter of drum		
Material in drum		
Diameter of sheaves		
Hp of motor at crane rating		
Rpm of motor at crane rating		
Make and type of motor		
Make and type of hoist limit switch		
Total lift above floor line. (Exclusive of travel required to operate limit switch)		
Total travel below floor line		
Brakes, number, make and size		
Make and type of bearings		
Make, size and type of worm gear drive, if furnished		

13. Trolley:

Speed, feet per minute with maximum working load.....
Wheel span.....
Wheel base.....
Diameter of wheels.....
Maximum wheel load.....
Size of trolley runway rail.....
Hp of motor at crane rating.....
Rpm of motor at crane rating.....
Make and type of motor.....

Make and type of brake, if furnished.....
Make and type of bearings.....
Make, size and type of worm gear drive, if furnished.....
Is foot-walk provided on ends of trolley?.....

14. Bridge:

Speed, feet per minute with maximum working load.....
Wheel base.....
Wheels, diameter.....
Number of wheels on each end of crane.....
Maximum wheel load.....
Make, type, size, and maximum load on wheel axle bearings.....
Number of motors.....
Hp of motors at crane rating.....
Rpm of motors at crane rating.....
Make and type of motors.....
Diameter of drive shaft.....
Make, type and size of line shaft bearings.....
Number and size of brakes.....
Make and type of brake operating equipment.....
Clear width of each foot-walk.....
Number of outrigger girders.....
Distance, centerline to centerline of girders.....
Type of sanding device, if furnished.....

Girders:

Submit design drawing showing overall dimensions, size of each section and location and depth of diaphragms.

15. Controls, make and type (if furnished by contractor):

Hoist motor.....
Bridge motor.....
Trolley motor.....
Location of magnetic control panels.....

16. Minimum distance centerline of main hook to centerline of runway:

Cab end.....
End opposite cab.....

17. Distance centerline to centerline of main and auxiliary hooks.....
18. Distance centerline between girders to extreme outside of crane:

Cab side.....
Side opposite cab.....

19. Distance, bottom of cab to floor.....
20. Clearances:

Bridge truck and building column.....
Trolley and roof chord.....

21. Make and type of flexible couplings.....
22. Size of cab.....
23. Maximum deflection of girders under maximum working load.....
24. Wiring, trade name, and classification of wire insulation.....

.....

ADDITIONAL COPIES OF THIS
CRANE SPECIFICATION SECTION
ARE AVAILABLE FROM

The Association of Iron and Steel Engineers

1010 EMPIRE BUILDING PITTSBURGH, PENNSYLVANIA

CRANE INDEX

A

Acceptance, Test and....CS-4
Accessibility....CS-5
Appendix....CS-18

B

Bearing brackets and housings....CS-13
Bearings....CS-12
Bearings, Tabulation, for track wheel axles....opposite CS-22
Blocks, Sheaves and hook....CS-10
Bolts, nuts and rivets....CS-15
Bracket and housings, Bearing....CS-13
Brakes....CS-14
Bridge end carriages....CS-8
Bridge brakes....CS-15
Bridge drives....CS-12
Bridge motor....CS-16
Bridge structure, Girders and....CS-5
Bumpers....CS-11

C

Cab, Operator's....CS-9
Cable reel, Magnet....CS-17
Changes or additions....CS-4
Clearances....CS-5
Collector shoes....CS-15
Combined bending moment....CS-6
Conductors....CS-15
Controls....CS-16

D

Disconnecting switches....CS-17
Drives, Bridge....CS-12
Drums....CS-10

E

Electrical details....CS-15
End carriages, Bridge....CS-8
Equalizer bar or sheave....CS-10
Erection....CS-4

F

Factor of safety, Materials and....CS-5
Foot-walks....CS-9

G

Gear covers....CS-14
Gearing....CS-13
General instructions....CS-3
Girders and bridge structure....CS-5
Guarantee....CS-4

H

Hoist brakes....CS-14
Hoist limit switch....CS-16
Hoist motor....CS-15
Hook blocks, Sheaves and....CS-10
Housings, Bearing brackets and....CS-13

I

Impact....CS-5
Information sheets....CS-25
Inspection, Workmanship, material and....CS-5
Interchangeability....CS-5

K

Keys, Press fits and....CS-12

L

Ladders, Stairs and....CS-9
Lateral forces....CS-5
Lifted load....CS-5
Lighting....CS-17
Limit switch, Hoist....CS-16
Lubrication....CS-15

M

Magnet cable reel....CS-17
Materials and factor of safety....CS-5
Mechanical details....CS-10
Motors....CS-15

N

Nuts and rivets, Bolts....CS-15

O

Operator's cab....CS-9

P

Painting....CS-5
Patents....CS-4
Press fits and keys....CS-12

R

Railings....CS-9
Rails....CS-11
Reel, Magnet cable....CS-17
Rivets, Bolts, nuts and....CS-15
Ropes....CS-10

S

Safety devices....CS-5
Safety, Materials and factor of....CS-5
Shafting....CS-12
Sheaves and hook blocks....CS-10
Shoes, Collector....CS-15
Signal lights....CS-17
Specifications....CS-3
Stairs and ladders....CS-9
Stress combinations....CS-6
Structural design....CS-5
Switch, Hoist limit....CS-16
Switches, Disconnecting....CS-17

T

Test and acceptance....CS-4
Torsional forces....CS-6
Track wheels....CS-10
Trolley brakes....CS-14
Trolley frames....CS-9
Trolley motor....CS-16

W

Welded construction....CS-5
Wheels, Track....CS-10
Wind load....CS-6
Wiring....CS-17
Workmanship, material and inspection....CS-5

for MAXIMUM CAPACITY IN MINIMUM SPACE

Interchangeable

WITH SINGLE-ROW BALL BEARINGS

NORMA-HOFFMANN

PRECISION ROLLER BEARINGS

NORMA-HOFFMANN BEARINGS CORP'N.,

STAMFORD, CONN., U. S. A. • *Founded in 1911.*

Write for the Catalog. Let our engineers work with you.

Their solid cylindrical rollers provide maximum contact area, giving larger load and shock-absorbing capacity than any other single-row bearing of like dimensions. Thus, when NORMA-HOFFMANN PRECISION ROLLER BEARINGS are used in place of ball bearings, a greater factor of safety is provided, together with added life, particularly under vibration and overload. PRECISION qualities in workmanship and materials adapt them alike for both low and high speeds.

The first outstanding feature you will note after you have purchased a Cleveland all-welded Crane is the ease and speed with which it is erected.

If it is of a type and size you would expect to require from 10 days to two weeks to erect, you will be surprised to see the Cleveland up and in operation in 5 to 6 days. If it's a large heavy-duty Crane with considerable electrical equipment that you know from experience ordinarily takes two to three weeks to install, you will be amazed to see the Cleveland complete and running in a week to 10 days.

The figures quoted are not exceptional but usual with Cleveland all-welded Cranes. They have been proved time and again on many large jobs where various makes of cranes have been installed at approximately the same time.

THE CLEVELAND CRANE & ENGINEERING CO.

1131 EAST 283RD STREET • WICKLIFFE, OHIO.

MANUFACTURERS OF • CLEVELAND CRANES • CLEVELAND TRAMRAIL • STEELWELD BENDING PRESSES

CLEVELAND *Steel Mill* CRANES

"I'm glad our cranes have **CRANE** *motors"*

"It's a real satisfaction to know that our cranes are designed to do *our* job in every particular. Built entirely in P&H shops, they're engineered as complete units with all motors and electrical apparatus designed solely for crane service — not adapted to it.

"It's good for my peace of mind to deal with a single, responsible supplier. To have no buck-passing on delivery or maintenance problems.

"That counts for something — especially during this emergency. And so do P&H's honest delivery dates."

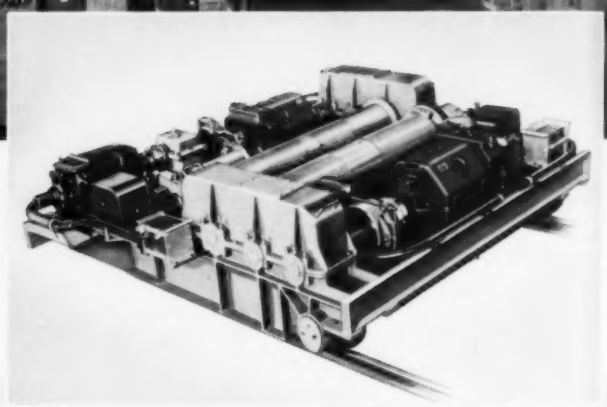
P&H is America's largest and only crane builder producing complete electrical equipment.

Awarded the Navy "E" for excellence in war production, P&H displays it also as a pledge of future effort.

General Offices: 4455 W. National Ave., Milwaukee, Wis.

HARNISCHFEGER
CORPORATION
ELECTRIC CRANES • EXCAVATORS • ARC WELDERS P&H HOISTS • WELDING ELECTRODES • MOTORS

Want a Lift?
See the Crane Section of SKF's "Steel Mill Data for Calculation and Design"!
SKF's self-aligning roller bearing with positive roller guiding is *the* crane bearing. It's compact . . . has high radial and thrust capacity . . . is unaffected by misalignment or deflection . . . requires no adjustment. SKF Industries, Inc., Philadelphia, Pa.
5125
STEEL MILL DATA for CALCULATION and DESIGN
SKF SPHERICAL ROLLER BEARINGS
SKF
BEARINGS FOR CRANES



MORGAN 60-TON, 100′ 0″ SPAN HEAVY-DUTY MILL TYPE CRANE

BUILT BY MORGAN *Engineering*

● Illustrated is one of two Morgan heavy-duty mill type cranes in a strip mill. Morgan superiority of design and construction is built into every part to insure many years of profitable service. They are equipped with fabricated welded trolleys and bridge trucks, hydraulic bridge brakes and anti-friction bearings throughout. Trolleys are of the gear box type using plain motors with flexible couplings. An auxiliary girder is provided for helping to support the cage, bridge motor and control units. Morgan engineers rely upon a highly skilled shop organization, modern equipment and progressive ideas in building heavy-duty mill type cranes.

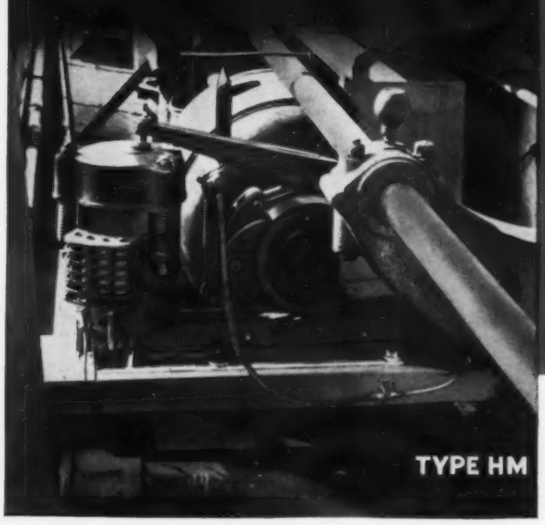
THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO. Pittsburgh, 1420 Oliver Bldg.

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

Are You Buying New Cranes?

IF SO—Specify COMPLETE WAGNER HYDRAULIC BRIDGE BRAKING SYSTEMS

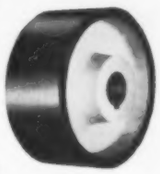


The Wagner Hydraulic Bridge Braking System is complete in every detail. It comes to you ready to install, and includes everything necessary — brake assembly, brake wheel, master cylinder, wheel cylinder, copper tubing, flexible hose, brake fluid and all fittings. The system is easy to install and any brake maintenance man can make the installation.

The Wagner Hydraulic Bridge Braking System assures positive braking action, smooth stopping, and controllable deceleration, to all types of overhead and whirler cranes. It will pay you to investigate if you are planning on new cranes or conversion from mechanical brakes.

BRAKE ASSEMBLY

Type H for inside cranes and type HM, where parking brake is necessary, for outside cranes.



BRAKE WHEEL

Furnished with bore as specified.

HYDRAULIC PARTS AND FLUID

All hydraulic parts and fluid needed for installation.

Write For Complete Literature

Bulletin IU-20 contains complete design, installation, adjustment, and service information on Wagner Hydraulic Bridge Braking Systems. This valuable bulletin should be in the hands of all design, production, safety, and maintenance engineers . . . Write for your copy today.

Branch Offices in 25 Principal Cities

MAIL COUPON TODAY

Wagner Electric Corporation 142-3 IESE
6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

Gentlemen:

Please send me my copy of ☐ Bulletin IU-20 on Wagner Hydraulic Bridge Braking Systems, ☐ and place my name on the list to receive the Wagner Brake-O-Gram (a periodical bulletin on the operation, care, and maintenance of bridge brakes.)

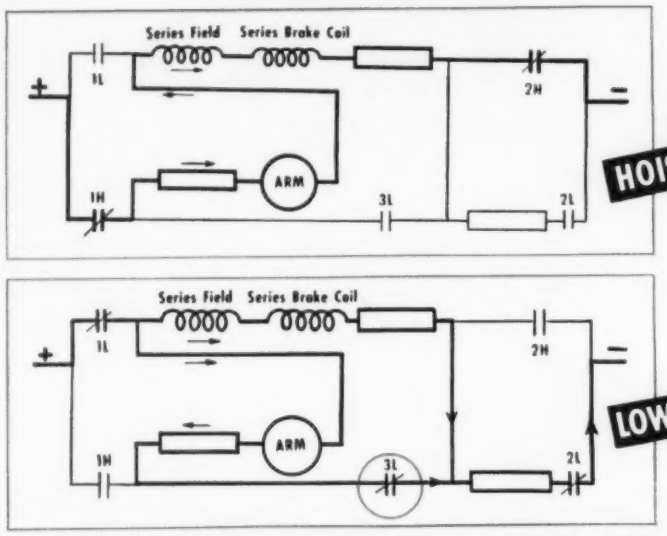
*Name*_____ *Position*_____

*Company*_____

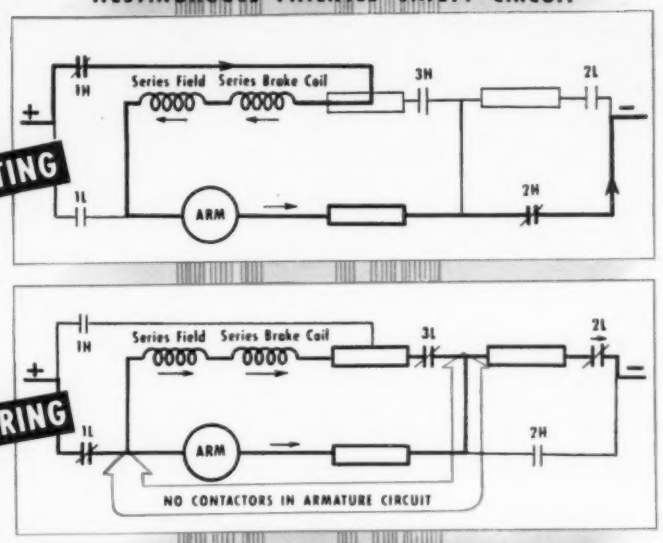
*City*_____ *State*_____

crane control without "IFS"

CONVENTIONAL CIRCUITS



WESTINGHOUSE PATENTED SAFETY CIRCUIT



Conventional crane control circuits employ a contactor in the armature circuit. They provide electrical interlocking only, to prevent the solenoid brake from releasing if the armature contactor fails to close.

If the armature circuit contactor should fail to make the circuit, due to worn contact tips or a broken contact spring, the load would drop.

Westinghouse Crane Control (Class 9635) employs no contactor in the armature circuit which could permit loss of dynamic braking control.

This safety feature is built right into the main circuit without the use of any interlocking. Complete safety is thus assured. Brake cannot be released or stay released without dynamic braking control of the load.

IF contactors wear or fail, as employed in the armature circuits of conventional control methods—accidents happen. Westinghouse Safety Circuit Crane Control eliminates this "if."

Conventional control circuits apply dynamic braking action when lowering, by reversing the armature. This necessitates the use of a contactor in the armature circuit. (See circled contactor "3L" in diagram.) Should this contactor fail to close the circuit for any reason, there would be no dynamic braking. The solenoid brake is held released by a separate field circuit and there is nothing to keep the load from dropping.

Westinghouse Crane Control eliminates the possibility of such a failure because it reverses the *field,* doing away with the use of any contactors in the armature circuit. (See diagrams.) Since there is no contactor to open in the armature circuit you always have dynamic braking control of the load whenever the solenoid brake is released.

Specify this safer crane control today! Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N.

J-21251

Westinghouse

CRANE CONTROL

BE SURE

Specify "Tool Steel"

Make certain that your crane specifications call for genuine "Tool Steel" . .

TRACK WHEELS

GEARS and PINIONS

BRAKE WHEELS

SHEAVE WHEELS

SHEAVES

These products have proven their superiority in every crane service over the past thirty years.

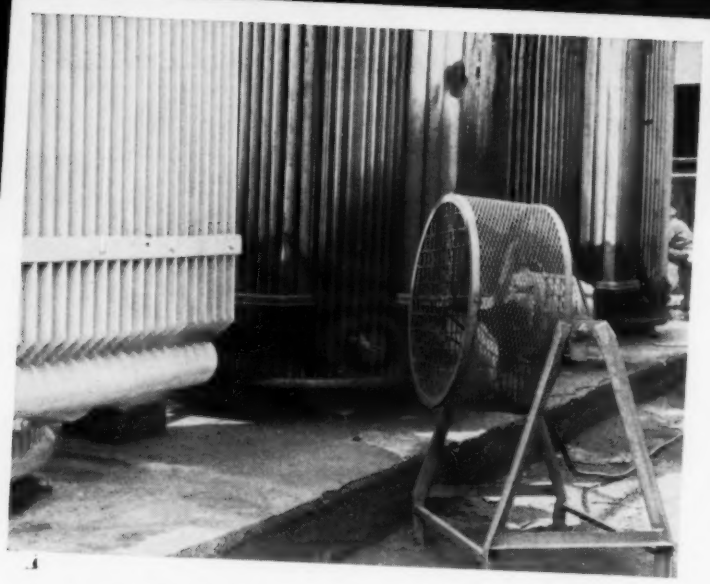
THE TOOL STEEL GEAR & PINION COMPANY

CINCINNATI OHIO

Let Truflo Fans . . .

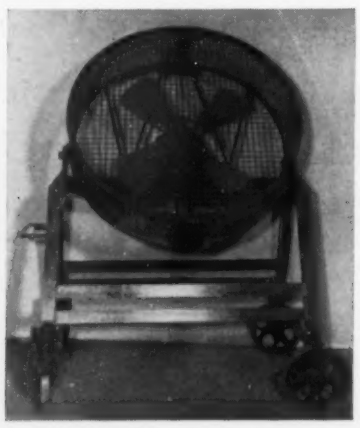
Help keep your workmen on their toes

Portable Fan No. TF-100, recognized as standard in many of the country's largest mills. Sizes from 12 in. to 36 in. in diameter.



Portable Fan No. TF-300 in operation, cooling large transformers in strip mill.

Crane Cab Fan, for cooling crane cab interiors and other confined areas. Available in 12 in. and 18 in. sizes, adjustable both horizontally and vertically.



Portable Fan No. TF-300W. Angle iron support adjusts for vertical or horizontal discharge through almost 360°.

It's more important now than ever before to keep your workmen comfortable. For comfortable workmen are more efficient, produce more work in a given time.

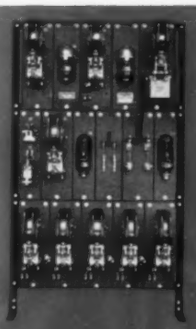
Truflo Fans can help you keep your workmen on their toes. All Truflo Fans are designed and built correctly for efficient, economical operation — they move more air per dollar. Write for free literature on any of the following styles:

Portable Cooling Fans • Crane Cab Fans
Wall Fans • Exhaust Fans • Blowers
Roof Ventilating Fans • Pent House Fans

TRUFLO FAN COMPANY

554 MAIN STREET HARMONY, PA.

Industry's **FIRST CHOICE** *for over 40 years*



MAGNETIC CONTROL
Bulletin 921

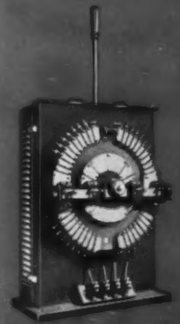
WHEN buying cranes, many firms write EC&M into the specifications, because they can't afford a shutdown. They want control designed for CRANES and they know EC&M specializes in crane equipment and has made many outstanding contributions resulting in greatly improved crane performance.

On heavy-duty ladle and stripper cranes as well as on smaller-capacity cranes in machineshops, etc., EC&M Control has a reputation for continuity of service at low up-keep. For proven performance, highly satisfactory to the entire plant personnel, specify EC&M Control when cranes are purchased.

THE ELECTRIC CONTROLLER & MFG. CO.
CLEVELAND **OHIO**

EC&M Contributions in Crane Control

1. The first dynamic lowering control for hoists
2. The Wright Dynamic Lowering Circuit—a great improvement in hoist control
3. Time-Current Acceleration
4. Duplex and Quadruplex Control for 2 and 4-motor drives
5. Line-Arc Contactors
6. A-c Dynamic Lowering Control for A-c hoists
7. A-c Contra-torque Control for A-c hoists
8. Frequency Relay Control for A-c wound-rotor crane motors
9. The first Protective Panel for all motors on the crane
10. Type WB Brakes—the first with heavy-duty, brake blocks



MANUAL CONTROL
Bulletins
960-A, 970-A, and 980-A

SAFETY LIMIT STOPS
Bulletin 1035-C

PROTECTIVE PANELS
Bulletins 1021-C and 1022

TYPE WB BRAKES
Bulletin 1004-C

WHITING CORPORATION

SHEPARD NILES
CRANE & HOIST CORPORATION

Bedford Foundry & Machine Company

THE WELLMAN ENGINEERING CO.

THE EUCLID CRANE & HOIST CO.

NORTHERN ENGINEERING WORKS

The Alliance Machine Company

THE CLEVELAND CRANE & ENGINEERING CO.

HARNISCHFEGER CORPORATION

MORGAN ENGINEERING COMPANY

SHAW-BOX CRANE & HOIST DIVISION
MANNING, MAXWELL & MOORE, INC.

ALL LOADS LEAD TO HYATT

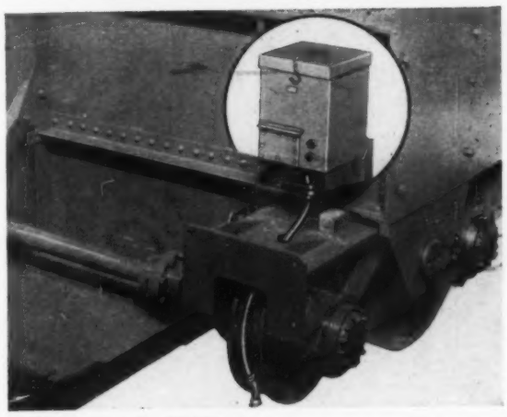
All leading builders of cranes for steel mills, industrial plants, and shipyards have used Hyatt Roller Bearings for years and years. Wherever load meets load under the added burdens of wartime pressure, Hyatts are giving dependable performance with a minimum of care and maintenance. Our engineering department will be glad to consult with you on any related problem. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

THE 50TH YEAR OF HYATT ROLLER BEARINGS

MAKE SURE THESE IMPORTANT ITEMS ARE INCLUDED IN YOUR SPECIFICATIONS

A.I.S.E. CRANE SPECIFICATIONS for Heavy Duty Mill Type Cranes

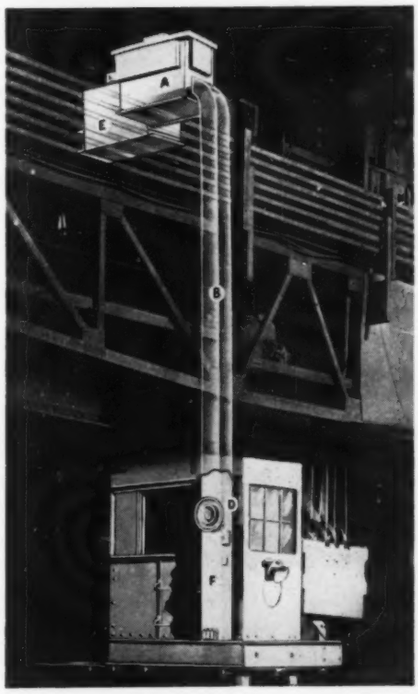
14. Is repair structure over trolley to be furnished.....
15. Are track sanders to be furnished **Yes, LINTERN-4 required-1 at each corner of crane.**
16. Bridge drive shall be in accordance with paragraph..... of clause No. 31



★For either outside or inside service, these sanders offer important advantages:

1. Provide sand instantly.
2. Avoid spinning wheels.
3. Reduce flange wear of wheels.
4. Prevent crane skids, misalignment.
5. Deposit sand directly in front of driving wheels.
6. Utilize all of the sand—no waste.
7. Stop sand flow when crane stops.
8. Require only infrequent filling.
9. Easily operated from cab.
10. Backed by 20 years of successful record.

35. Is heat shield under cab to be furnished.....
36. Size or capacity of heating and ventilating unit for cab to be furnished **LINTERN-AIRE Conditioner No. 124-3-36** **Where mechanical cooling is not required, use No. 130-V Ventilating Heater.**
37. Location f.....



A—Filter-Blower unit. E—Condenser unit. B—Duct leading to cab. D—Cool, clean air comes out here, directed as, and in whatever volume and velocity operator wants. F—Heater unit installed here.

50. Collector shoes are to be made in accordance with accompanying drawing N
51. Signal lights as follows shall be furnished..... **LINTERN No. 700-EM red and green lens—No. 580 switch.**
Method of attaching girders to end carriages at field erection shall be.....

★Lintern Aire Conditioners supply clean, cool air to hot metal crane cabs, eliminate all gas fumes, including harmful dust, thereby greatly improving cab conditions. Valuable 365 days in year since clean, filtered, heated air is supplied during cold weather. Used nationwide—all engineering, installing and checking under competent factory supervision

Lintern Crane Signals protect lives of operators and crane repairmen. Users find them valuable to the operating man, in signaling at all times the condition of all cranes on the runway.

THE LINTERN CORPORATION · 54 Lincoln Avenue, Berea, Ohio

Give your cranes increased speed, strength and endurance for Victory and post-victory requirements. Equip them with Timken Bearings throughout.

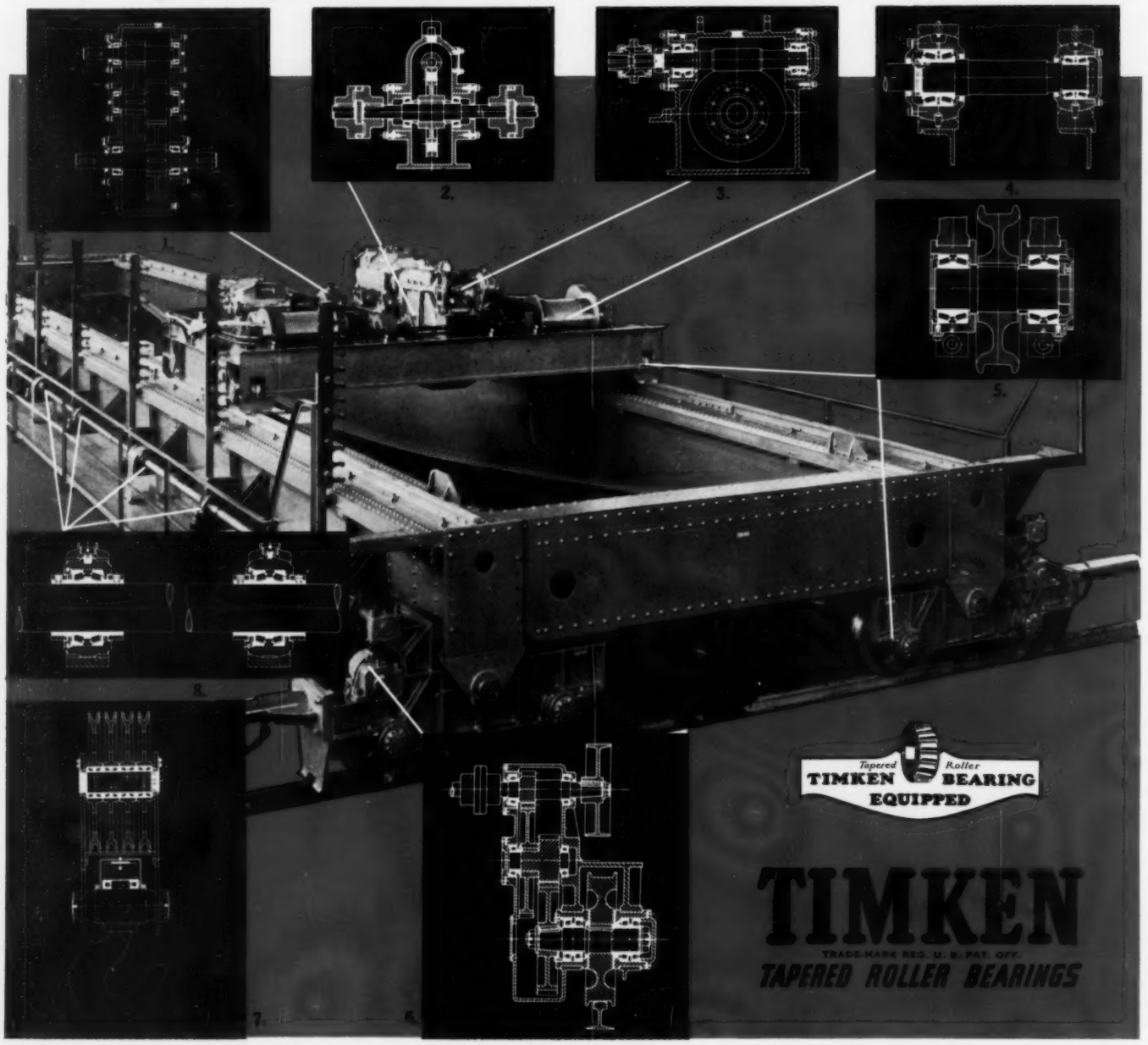
A few Timken Bearings are better than none in any crane; even if you have them only in the bridge and trolley track wheels your cranes will perform better, last longer, cost less for upkeep.

In order to get the *full* benefits of Timken Tapered Roller Bearings however, you must have them *at every bearing position*. Then every moving part will be completely protected against friction; wear; radial, thrust and combined loads, and misalignment. Then your cranes will consume less power; require less lubrication; operate faster; stand up longer; need less time out for maintenance.

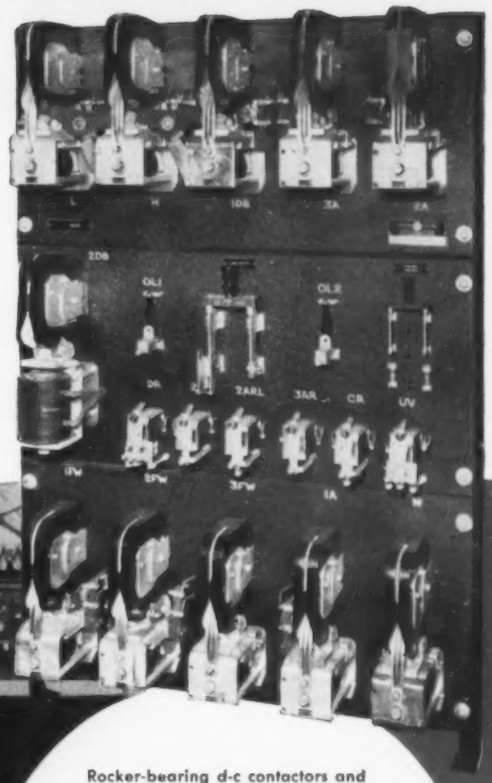
When buying overhead cranes of any size and capacity for any purpose, it will pay you to specify Timken Tapered Roller Bearings for all positions including those listed below.

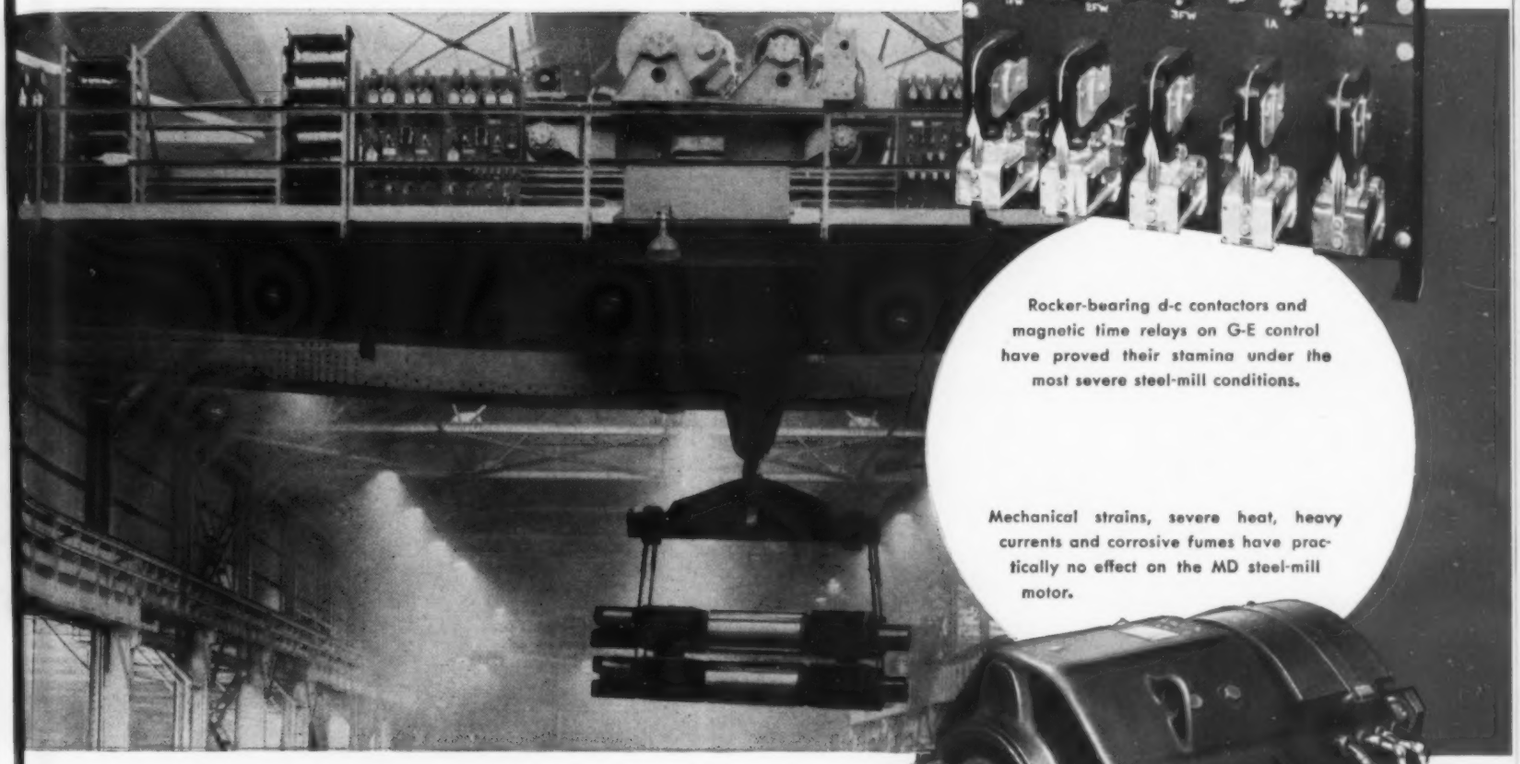
THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

Crane built by Morgan Engineering Company, Alliance, Ohio, showing the application of Timken Bearings at the following positions: 1. Trolley travel drive; 2. Hoist drive worm gear shaft; 3. Hoist drive worm shaft; 4. Hoist drum shaft; 5. Bridge and trolley track idler wheels; 6. Bridge drive and driven axle; 7. Hook block; 8. Bridge drive line shaft.



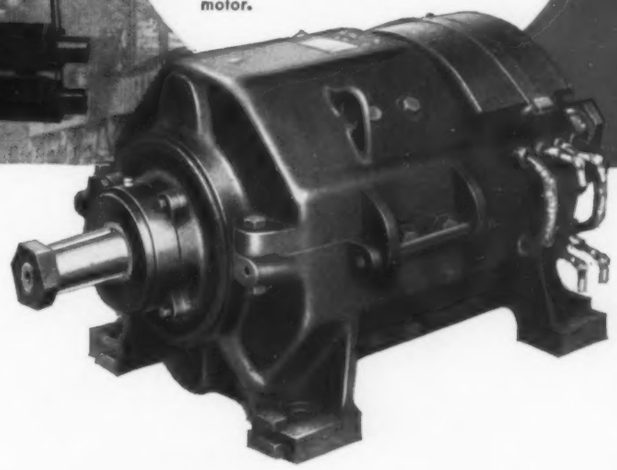
For Smoothness and Precision
SPECIFY
G-E CRANE CONTROL





Rocker-bearing d-c contactors and magnetic time relays on G-E control have proved their stamina under the most severe steel-mill conditions.

Mechanical strains, severe heat, heavy currents and corrosive fumes have practically no effect on the MD steel-mill motor.



Regardless of the operation—handling molten steel, changing rolls, stripping, or handling coils—you will find G-E crane motors and control give smooth, precision performance. A "peck touch" on the master switch will move the motor armature as little as a quarter turn.

Excessive mechanical shocks are prevented by three time-controlled deceleration points while lowering and by counter-emf control of acceleration for both hoisting and lowering. Dynamic braking is always available on all OFF and lowering positions—even if power fails. Speed adjustments for lowering are independent of adjustments for hoisting. Deceleration relay adjustments are independent of acceleration relay adjustments.

This *precision* control means less wasted time in "spotting" crane loads—time which is needed for increased production. This *smoothness* of control materially reduces current peaks with their accompanying mechanical strains, resulting in lower maintenance.

In the matter of engineering service, our field staff in recent years has been enlarged to meet the increased requirements of the steel industry. Backed by G-E research facilities and accumulated technical skill, these men can assure you of the performance you demand. *General Electric, Schenectady, N. Y.*

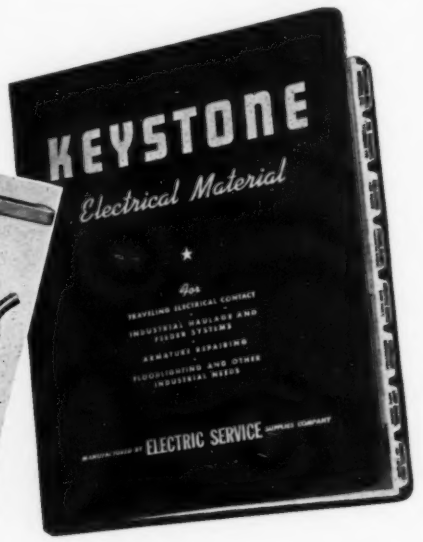
The Navy "E", for Excellence, has been awarded to 92,780 General Electric employees in six plants manufacturing naval equipment.

GENERAL ELECTRIC

Headquarters

For Traveling Electrical Contact and Heavy Feeder System Materials

★ Contact Rail Shoes or Collectors and Insulators are vital in the operation of cranes and other haulage systems. Strain Insulators and Clamps are essential for heavy feeder systems. Orders for these materials exceed production and we suggest that you anticipate your future needs (including spares for emergencies) so that we can keep you supplied and not hold up your production.

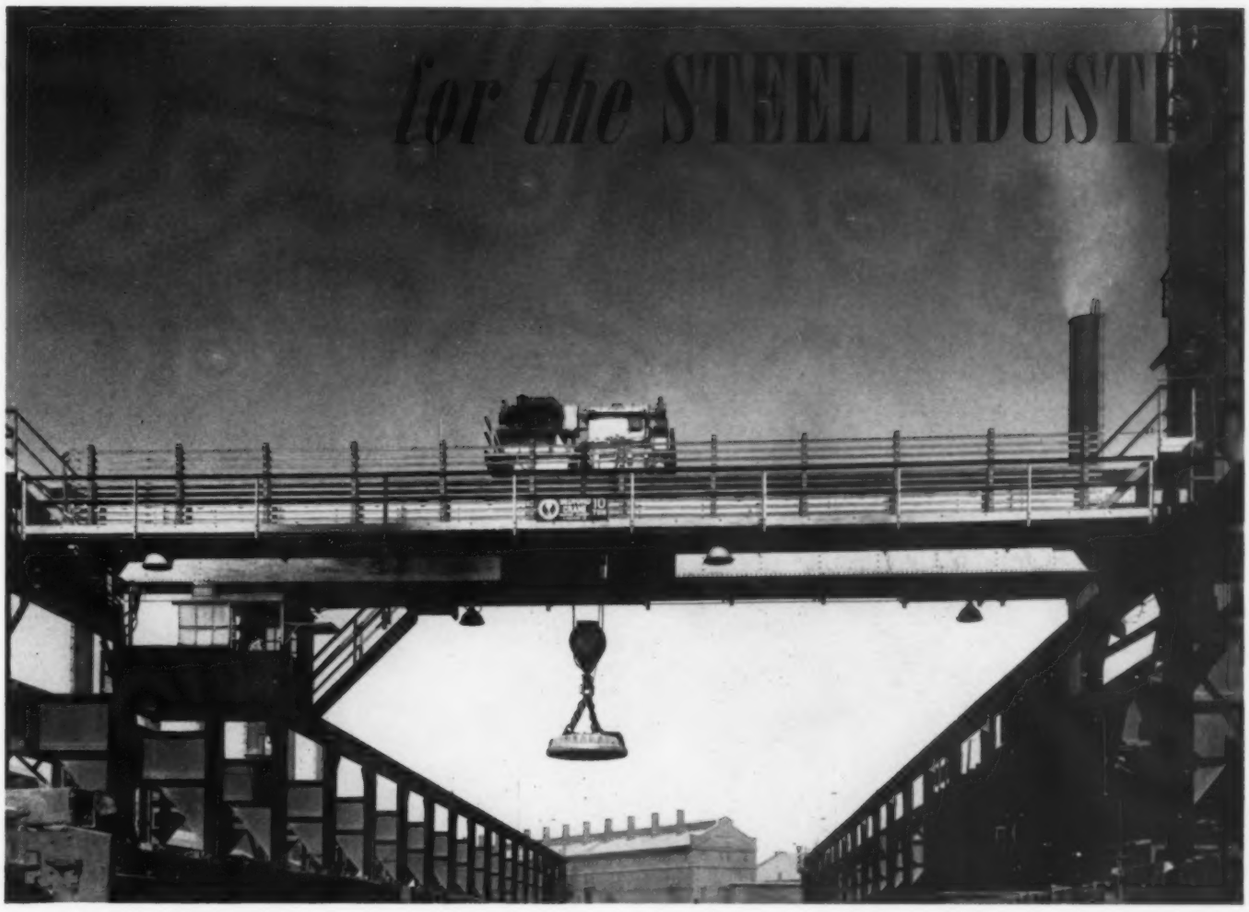


Catalog and Prices
Sent Promptly on Request

MANUFACTURED BY **ELECTRIC SERVICE** SUPPLIES COMPANY

17th & CAMBRIA STREETS • PHILADELPHIA • PA. • BRANCHES IN PRINCIPAL CITIES AND FOREIGN COUNTRIES

CRANES *that do a job*



This 10-ton heavy duty mill type Bedford magnet crane, of 71 ft. 9 in. span, is fitted with mill type motors, roller bearings, worm-driven hoist, one-shot lubricating system, angle bar conductors, and full magnetic control.

Through their daily performance, BEDFORD CRANES have won orders and re-orders from leading steel companies. The inherently correct design and rugged construction entering into all BEDFORD CRANES assure uninterrupted service, minimum maintenance, and long life.

BEDFORD CRANES SERVICE

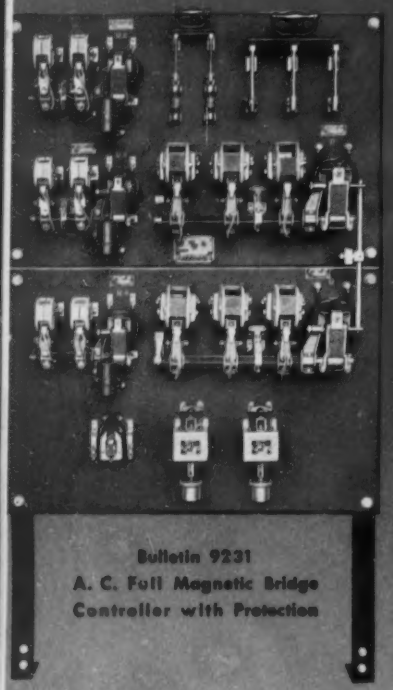
ELECTRIC OVERHEAD TRAVELING CRANES OF ALL DESCRIPTIONS

Bedford Foundry & Machine Company

INCORPORATED

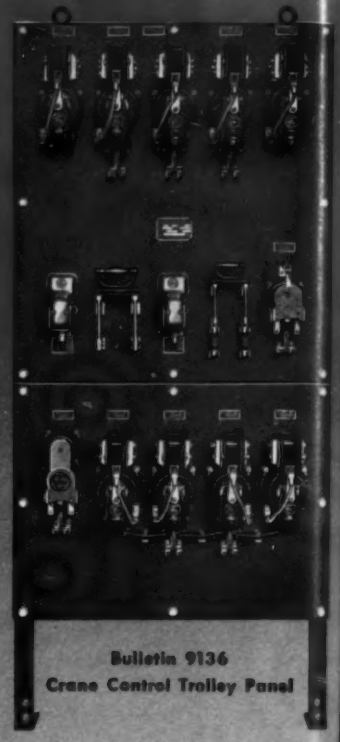
GENERAL OFFICES — **Bedford, Indiana**

THOUSANDS OF "3C" CRANE CONTROL PANELS, BRAKES AND



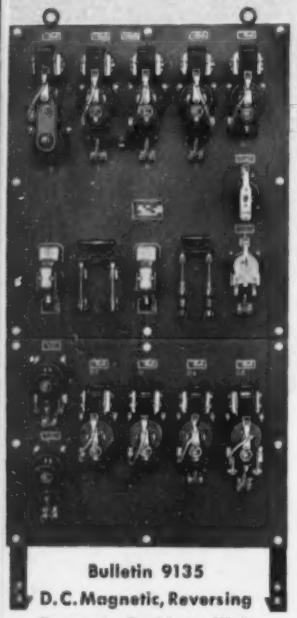
Bulletin 9231
A. C. Full Magnetic Bridge
Controller with Protection

Installation View "3C" Standardized D. C. Magnetic Crane Controllers



Bulletin 9136
Crane Control Trolley Panel

Bulletin 101 Type
R. D. Mill Master Switch



Bulletin 9135
D.C. Magnetic, Reversing
Dynamic Braking, High
Speed Lowering Control
Panel

CONTINUOUS TESTING AND DEVELOPMENT KEEPS "3C" HOISTS "ON THE BEAM"

- At the "3C" plant, an Experimental Hoist is a permanent part of the Development Department equipment.
- This hoist permits development of control on both A. C. and D. C. motor drives.
- Graphic records of performance of existing equipment are kept, as well as the performance of proposed new schemes of operation.

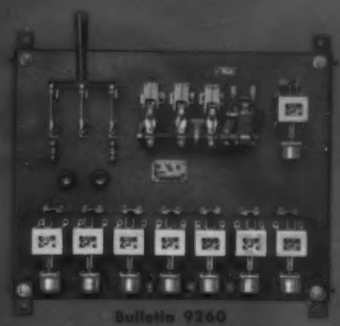
CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

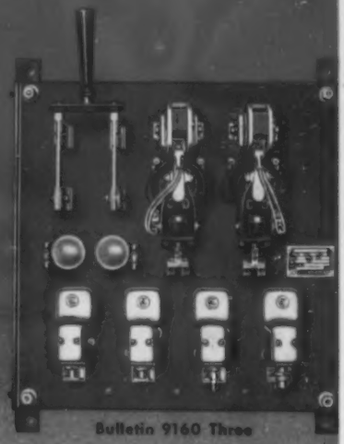
1146 EAST 152ND ST. CLEVELAND, OHIO

AND ACCESSORY DEVICES IN SUCCESSFUL OPERATION

Bulletin 102 Type CHL
Crane Hook Limit Switch

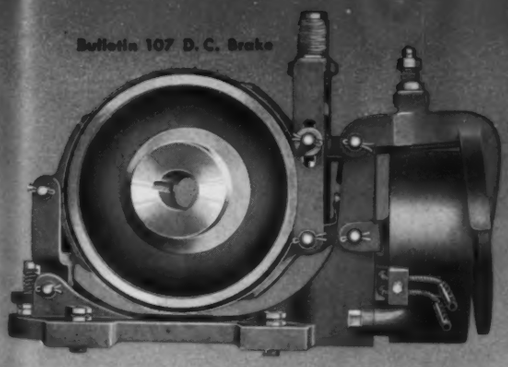


Bulletin 9260
Four Motor Standard A.C.
Crane Protective Panel
with two Overload
Relays for Each Motor

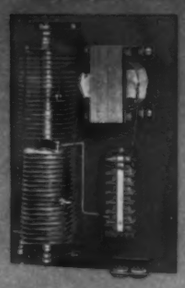


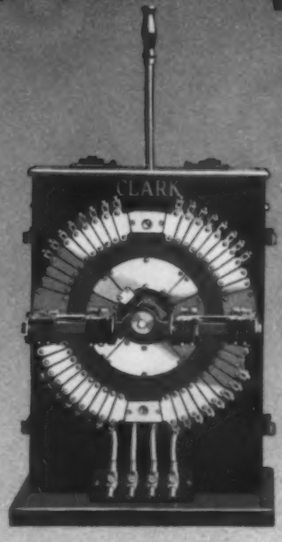
Bulletin 9160 Three
Motor Standard D. C. Crane
Protective Panel with Common Return Overload Relay

Bulletin 107 D. C. Brake



Brake Rectifier Unit





Bulletin 9150 Plain
Reversing D. C. Manual
Face Plate Controller

Bulletin 110
Edgewound Resistor

¶ Thousands of cranes owe their efficient operation to "3C" crane control and "3C" brakes.

¶ "Stepped-up" production demands increasingly efficient crane operation, and "3C" apparatus for A. C. or D. C. motors delivers service with minimum maintenance.

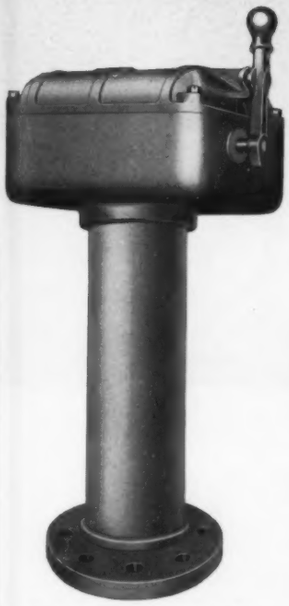
Bulletin 9250 Plain
Reversing A. C. Manual
Face Plate Controller

Welded End Terminal
on Edgewound Resistor

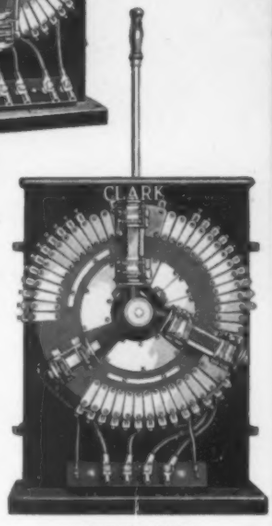
¶ Pictured on these pages are typical examples of "3C" apparatus. The story of their successful operation is being written day and night in steel mills and heavy industries whose products are essential to war production.

¶ High speed, heavy duty work, or delicate inching or placing are all the same to "3C" crane control.

¶ Consult our nearest office for details.



Pedestal Type Bulletin 101
Mill Master Switch



Bulletin 9150
Dynamic Braking D. C. Manual
Face Plate Controller

CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, OHIO

BE A
WASTE
WARDEN
Make this your pledge!
I WILL close cylinder valves after use.
I will check hose and connections for leaks.
I will keep tips clean and free from carbon and slag.
I will return empty cylinders, with their caps on, promptly.
I WON'T use excessive pressures.
I won't use oversize tips.
I won't leave torches burning when not in use.
I won't abuse cylinders.
I won't leave cylinder valves open when gas is not being used.
FIGHT WASTE TODAY
FOR VICTORY TOMORROW!

"FIGHT WASTE" POSTERS are playing a vital part in conserving essential materials — they are constant, practical reminders on "how to" make a little go a long way. » » Reproduced above is the latest of a series of 4-color posters Airco is making available. By observing their "do's" and "dont's" some plants are saving as much as 25% in oxygen and acetylene consumption. » » These posters are available in any quantity on request to your nearest Airco office, or by writing to Mr. G. Van Alstyne, Air Reduction, 60 East 42nd Street, New York, N. Y.

AIR REDUCTION

AIRCO

60 EAST 42nd STREET, NEW YORK, N. Y.

In Texas: Magnolia-Airco Gas Products Co.

IDLE CYLINDERS ARE PRODUCTION SLACKERS: KEEP 'EM ROLLING FOR VICTORY!

YOU GET THESE FEATURES IN P-G *Steel Grid Resistors*

★ All Steel Construction

★ Mica Insulation

★ Unaffected by Moisture

★ Provision for Expansion

★ Corrosion Resistant

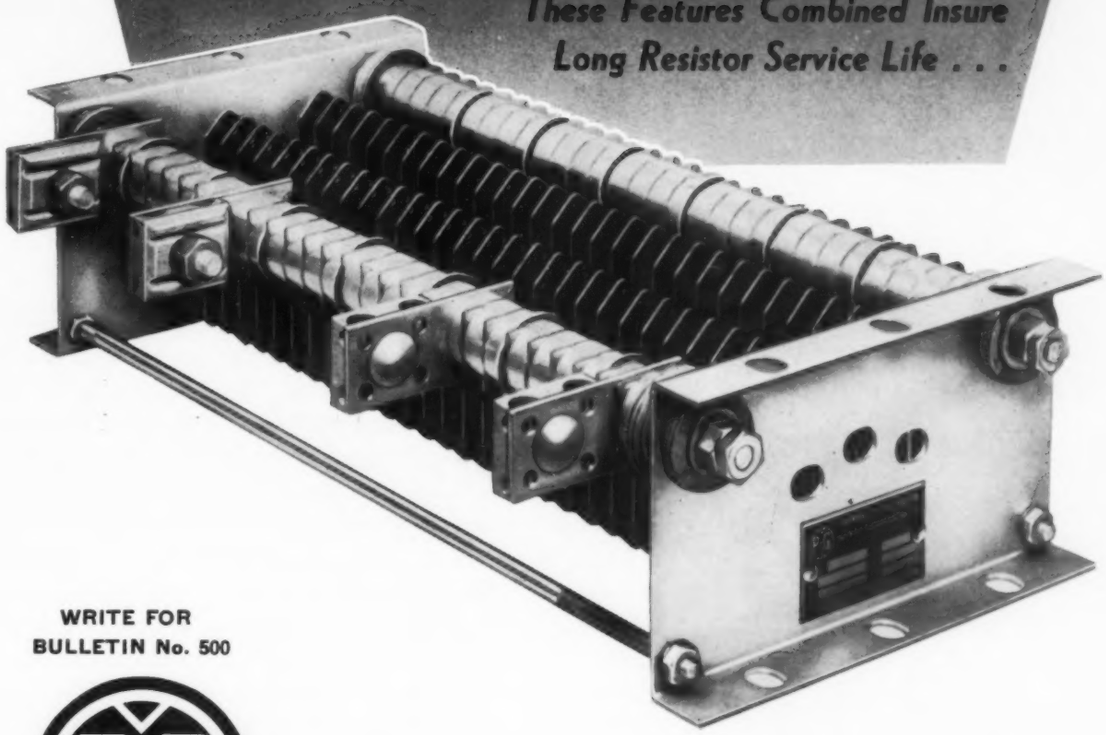
★ Maximum Ventilation

★ Constant Resistance

★ Withstands Vibration

★ Rugged Terminals

These Features Combined Insure Long Resistor Service Life . . .



WRITE FOR BULLETIN No. 500

P-G

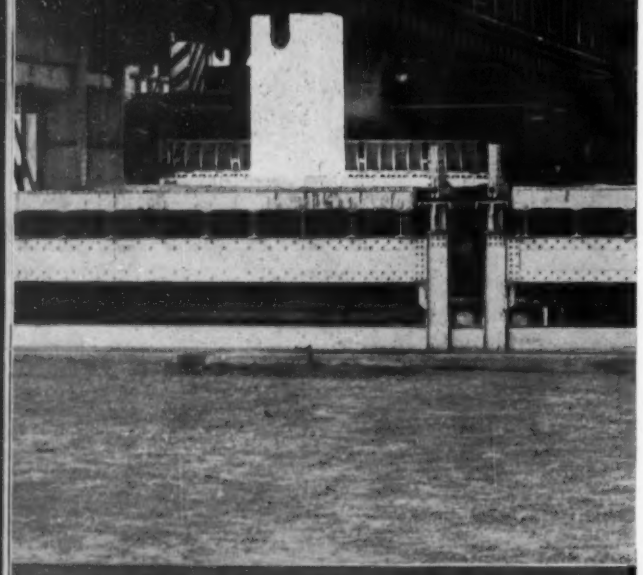
"The Resistor you can Install and Forget"

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI, OHIO

HOW TO SELECT A *Crane*



A Soaking Pit Crane in one of America's Steel Plants

LADLE CRANES, GANTRY CRANES
FORGING MANIPULATORS
SOAKING PIT CRANES, STRIPPER CRANES
SLAB AND BILLET CHARGING MACHINES
OPEN HEARTH CHARGING MACHINES

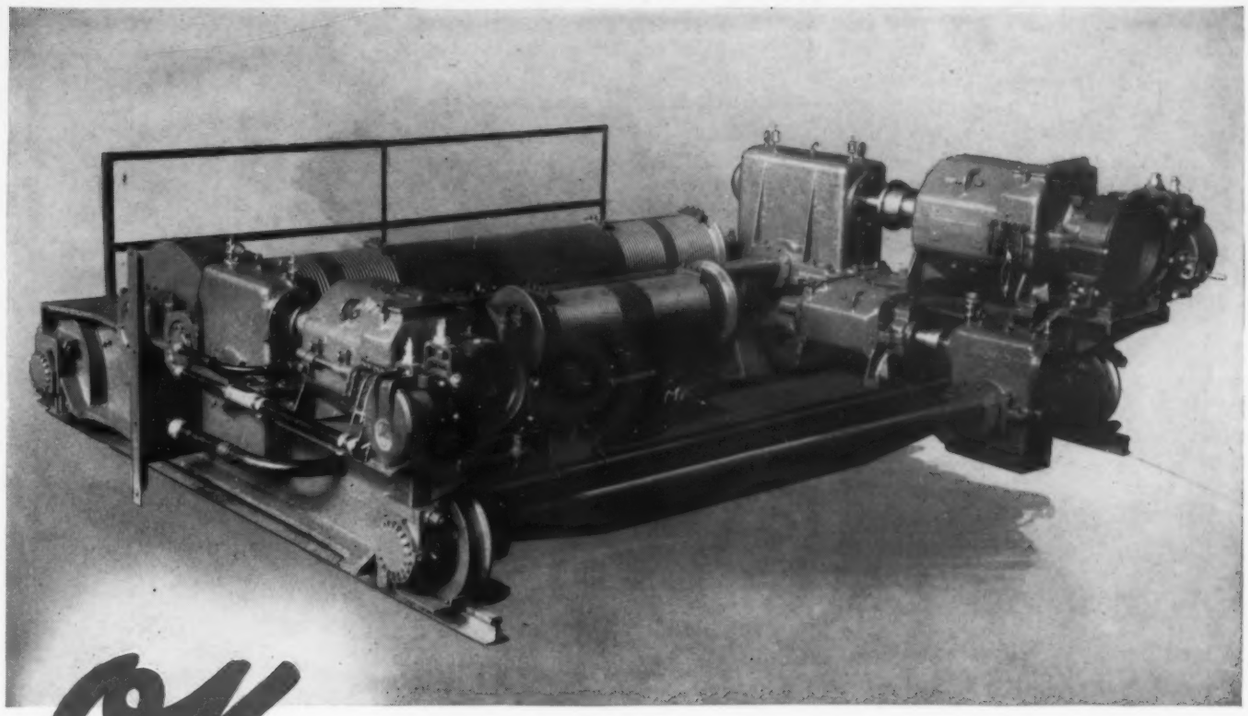
TO MEET YOUR 7 VITAL REQUIREMENTS . . . .

The duties and performance of your steel mill cranes are far-reaching. They must fit into the physical limitations of your plant or mill. At the same time, they should dovetail into your manufacturing methods, the speed of your production, and your tonnage. They become a connecting link and have to synchronize your different operations, reduce costs, and deliver dependable service 24 hours a day, 7 days a week. A crane to meet ALL THESE SEVEN CONDITIONS for you can be designed and built ONLY after complete information has been obtained by experienced crane engineers. Ready-made or standard assemblies will not do it. By calling upon Alliance engineers, you will benefit by their broad experience. They will lead the way to crane equipment that will meet your 7 vital needs.

THE ALLIANCE MACHINE CO. • ALLIANCE, OHIO

Alliance

SPECIAL AND STANDARD CRANES FOR HEAVY DUTY



OK'd by the Industry for 20 years-

CLEVELAND DRIVES
ON CRANE HOISTS AND TRAVEL

Ok'd in the early 1920's—when Cleveland first applied Worm Gearing to main and auxiliary hoists and trolley travel drives on Steel Mill Cranes.

Ok'd ever since—because, on cranes and scores of other tough applications throughout the Mill, Clevelands proverbially absorb heaviest shock loads year after year at little or no cost for parts replacement.

Throughout your own Mills you doubtless have many Clevelands giving your machines the unfaltering support they must have to maintain your present twenty-four hour schedules. You can always depend on Clevelands.

The Cleveland Worm & Gear Company,
3278 East 80th Street,
Cleveland, Ohio.

Affiliate: The Farval Corporation, Cleveland, Centralized Systems of Lubrication.
In Canada: PEACOCK BROTHERS LIMITED

CLEVELAND WORM GEAR *Speed Reducers*

1,000 Cranes in less than 5 minutes!

Each one of a thousand Farval-equipped Cranes receives complete and positive lubrication in less than 5 minutes and —not a bearing is missed.

An overhead crane shutdown can be as serious as the stoppage of any floor-level machinery. Centralized lubrication therefore is more essential on the isolated overhead equipment, which cannot be inspected from the floor and where you may risk serious injury to lubricate the hard-to-get-at bearing.

With Farval every bearing gets proper attention from a safe central point protecting all bearings between mechanical inspections. Farval also:—

Reduces labor of oiling 90% . . . Delivers clean grease and prevents over-lubrication . . . Eliminates drippage . . . Gives more time for a better job of inspection.

Protect your overhead Cranes—keep them rolling on 24-hour schedules. *Install Farval!*

The Farval Corporation, 3278 East 80th Street, Cleveland, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Automotive and Industrial Worm Gearing.
In Canada: PEACOCK BROTHERS LIMITED

FARVAL
CENTRALIZED SYSTEMS OF LUBRICATION

Manufacture of ELECTRIC RESISTANCE WELDED PIPE *and* TUBING

...the Johnston process, employing localized heating through electric resistance, in combination with pressure, is used for a complete range of tubing and pipe...

By J. S. Adelson

CHIEF METALLURGIST
STEEL AND TUBE DIVISION
REPUBLIC STEEL CORPORATION
CLEVELAND, OHIO

Presented before A. I. S. E.
CLEVELAND AND YOUNGSTOWN SECTIONS

▲ THERE are a number of manufacturing processes for making pipe and tubing. Some of them require the flat-rolled steel or skelp to be heated prior to welding. Others combine the application of heat with pressure to the immediate surfaces to be joined.

Electric resistance welding falls into the latter category. It is a type of forge welding in which the edges or surfaces to be welded are raised to a welding temperature and pressure applied in the same way that a blacksmith makes a forge weld.

The process used in the manufacture of electric resistance welded pipe and tubing by the Steel and Tubes Division of Republic Steel Corporation has been in operation for a number of years. It is referred to as the Johnston process, after its inventor, and was originally developed for the manufacture of so-called mechanical tubing, light wall tubing with a maximum thickness of 16 gauge or 1/16 in., such as is used in furniture, bicycles, automotive parts, and similar applications.

Many millions of feet of this pipe and tubing have been welded, from 1/2 in. in diameter with 0.025 in. wall to the 16 in. diameter by 0.5 in. wall by this process. In no instance, regardless of the type of equipment involved, has it been necessary to favor the weld which has been as strong as the base metal and with properties comparable to those of the base metal.

Boiler tubes carrying the Steel and Tube's trade name of Electrunite were introduced about ten years ago and today are in service in all types of installations

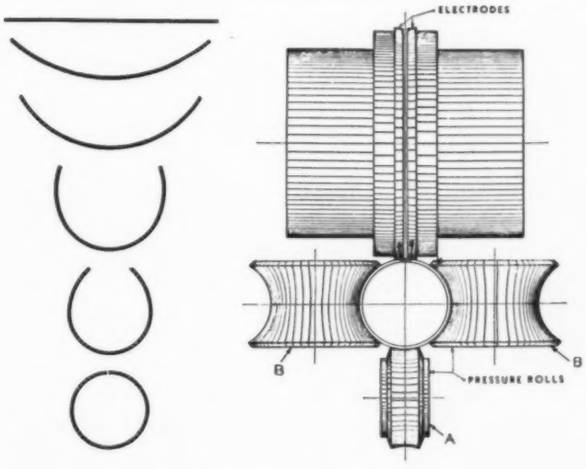


Figure 1 — The application of rolls on both sides and beneath the welding electrodes force the heated tube edges together to form the weld. By gradually forming flat steel into tubular shape, as shown to the left, undue strain of the material is avoided.

Figure 2 — The final forming rolls for the tubing.

— stationary power boilers, locomotives, heating boilers, and marine service.

The process used in the manufacture of these boiler tubes is basically identical with that used for small diameter, light gauge, mechanical tubing, or for the large diameter heavy wall pipe. Only variations are in heat treatment (mechanical tubing is generally used directly as it comes from the welding machine whereas all boiler tubing is normalized) and in the method of inspection and testing which are governed to some extent by the application to which the tubing is to be put.

Hot-rolled steel which has been pickled to remove all scale is the raw material used. Cold-rolled scale-free steel is generally used for light wall tubing and plate is used for heavy wall pipe. The steel is received in long coils with edges trimmed or sheared so as to have a uniformly accurate width throughout the coil. The plates used for heavy wall pipe cannot, of course, be coiled and consequently are run through the welding machine as single plates.

The steel is thoroughly inspected both at the mill and upon arrival at our plant for surface defects, temper, gauge, width, etc. The operation from this point forward is continuous — with the forming, welding, and sizing units contained in one massive machine.

The flat-rolled steel is fed cold into the forming section, which consists of a series of roll passes to form the flat stock into a butted cylinder which is then immediately propelled into the welding section.

The welding unit is the heart of the machine and is composed of a pair of discs or circular electrodes insulated from each other and mounted on a single horizontal shaft. Each of the electrodes makes contact on its side of the butted seam. Directly under the electrodes

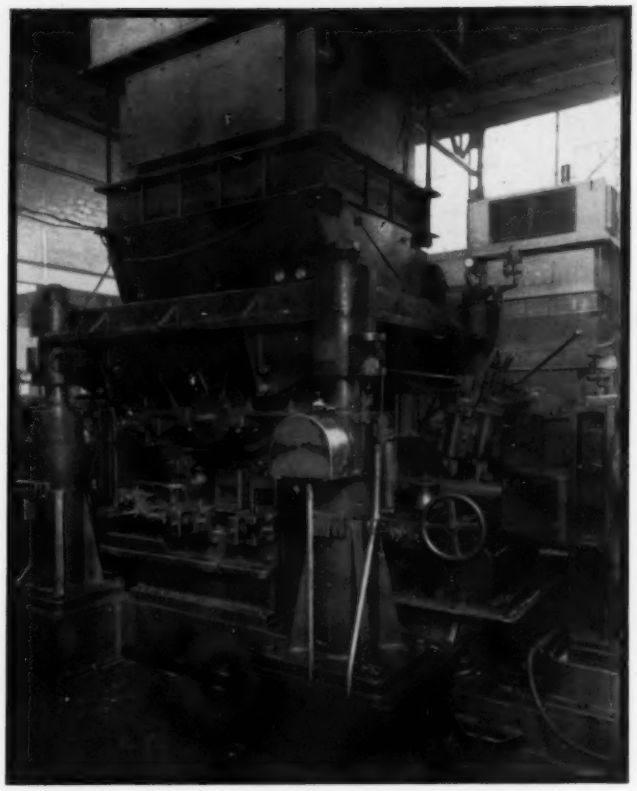
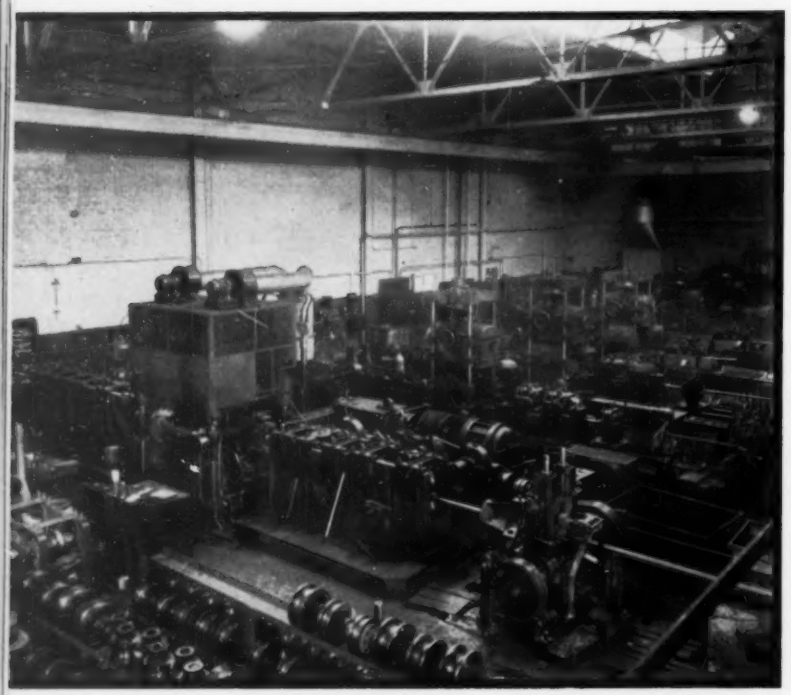


Figure 4 — The tube welding machine. To the right above the tube as it emerges from the welder can be seen the tools for removing the outside flash, leaving a perfectly smooth surface.

▲

Figure 5 — Close-up of the welding operation.

Figure 3 — The welding room, with machine in foreground which forms tube from flat steel, welds it, trims off burrs, and cuts the tubing in mill lengths.



is a pair of hardened steel rolls, mounted separately on vertical shafts. Each roll has a groove of the same contour as the circumference of the tube and is mounted so as to surround the tube for a distance of about 90 degrees.

Electric current of relatively high amperage is fed to the electrodes and through them across the tight-butted seam of the tube. The welding heat is generated by the resistance of the joint to the flow of the current. Mechanical pressure is applied by the supporting rolls at the instant of welding and the weld is immediately completed. There is no fusion of metal except possibly at the extreme contacting edges. No extraneous metal is added during the welding operation, the weld resulting solely from the union of the butting edges. The composition of the weld, therefore, is identical with that of the base metal.

The welding process consists essentially of correlating the speed, electric current, mechanical pressure and contact so that the heat is confined to the edges of the material. The area which appears red hot to the naked eye extends for only a distance of $\frac{1}{8}$ to $\frac{1}{4}$ in. on each side of the joint.

A microscopic examination of a section of tubing taken directly from the welding machine without any subsequent heat treatment discloses that the structural change, that is, the change in microstructure resulting from the welding heat, extends even less than $\frac{1}{8}$ in. on either side of the joint. This area is seldom over 1/10 in. wide and more generally is about $\frac{1}{16}$ in. wide. There is a slight increase in the size of this area in the very heavy wall tubes; but it is much less than anticipated considering the difference in wall thickness between the light and heavy wall tubes.

The structure itself is of interest. Whereas a cast structure is typical when metal is molten to form a weld (as in fusion welding) and this cast structure has a sharp grain formation, the grain structure in the vicinity of the weld on this tubing remains more or less rounded, with some carbon diffusion.

In other words, the welding heat has put the steel into solid solution and the rapidity of the cooling operation has resulted in the equivalent of a quenched steel. This accounts for the strength and ductility of the welded area. An anneal or normalizing treatment above the critical temperature produces complete recrystallization of the weld area, and it is generally impossible to locate the weld under the microscope after heat treatment.

This process is completely mechanical, once the operator has obtained the proper set-up. The welding factors of current, speed, pressure and contact remain constant. The tube is actually welded slightly oversize and is reduced to the finished dimension in the sizing section of the machine. This consists of a series of roll passes of the exact diameter desired. These roll passes also round up the tube.

Expansion and flattening tests are made at the start of each new coil or length of steel and are then taken periodically as the tube is being welded. Where there is any indication whatsoever of failure at the weld, the

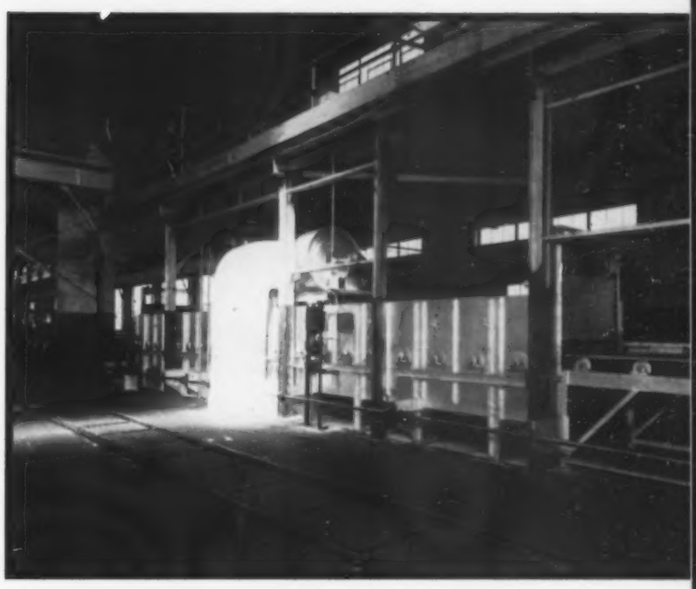
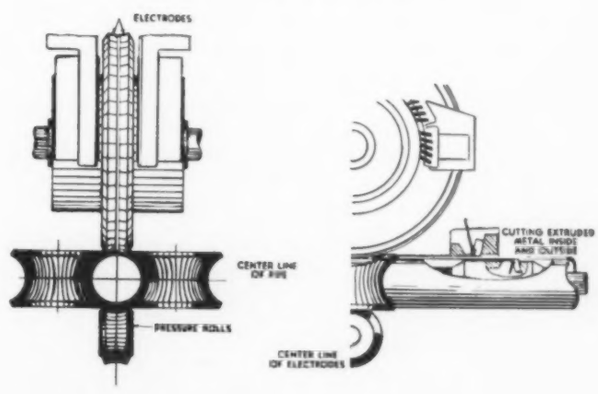


Figure 6 — Following normalizing, the tubes are carried directly into a bluing oven where they are coated with an extremely thin, tightly adherent, blue oxide which is uniformly distributed over the surface.

tube is scrapped and all preceding and succeeding tube is likewise scrapped until the machine operator has adjusted his machine to produce a weld which is free from defects. It is unnecessary to adjust the welder for each coil since the steel is run by heats and experience has proved that when a set-up is obtained on the first coil it is rare, indeed, that any difficulty is encountered with succeeding coils. Nevertheless, tests are taken continually as insurance against a defective section of tube being passed.

Figure 7 — Diagram of electrodes and welding rolls is shown to the left. The trimming of both inside and outside burrs is shown to the right.



A flash or upset is extruded on both inside and outside of the tube as a result of the pressure applied in making the weld. The amount of extruded metal in tubing welded by the Johnston process is much less than would normally be expected on the particular wall thickness being welded. The outside flash is removed with a cutting tool as the tube leaves the welder, resulting in a perfectly smooth exterior surface.

When production was first started on Electrunite boiler tubes, the inside burr was forged or rolled down while still hot. Within a year after production was started on boiler tubing, however, our engineers developed a method for removing the inside flash with a cutting tool immediately after the welding operation which is much superior to this.

The inside flash is not cut flush with the tube because of the normal variation in inside diameter and the difficulty of having an adjustable tool to compensate for this variation. It would be detrimental to cut into the wall of the tube and the cutting tools are, therefore, adjusted for a maximum height of 0.010 in. The height of the flash now varies between 0.000 in. and 0.010 in. Experience has proved that this slight amount does not interfere with rolling in the tubes or with any type of flue cleaner used on the inside of the tubing. The inherent ductility of the weld is readily evident in the character of the chips formed when removing the flash. Instead of breaking into small pieces, the flash comes off as one continuous chip.

The tube is cut to the approximate length desired on an automatic press or lathe synchronized with the welding speed. This makes it unnecessary to stop the welding machine either to obtain test pieces for inspection or to cut each length of tube. The welder is not stopped once a coil of steel is fed into the machine, except at the discretion of the inspector in the event that there are mechanical or surface defects, such as scratches, or unless the inside flash is not being properly trimmed, or the size is incorrect. The tube is under continuous inspection during the welding operation.

While mechanical tubing is generally used directly as it comes from the welding machine, all boiler tubing is normalized. This consists of heating it above the upper critical temperature of 1650 F, followed by cooling in air. The treatment gives the steel a fine grain size which means it is ductile and easy to roll in, yet tough and uniform in physical properties. All the effects of cold working caused by forming the butted tube and sizing after welding are removed, and complete recrystallization of both the base metal and the weld is produced. As previously stated, it is practically impossible to locate the weld under the microscope after heat treatment because the structure is so uniform throughout.

The first boiler tubes produced were normalized in a conventional type furnace and then pickled to remove all scale. However, to retain the original finish on the tube, which the pickling operation has a tendency to remove, it was necessary to install a controlled atmosphere furnace. Subsequently, a second such furnace was put into operation. The first furnace was an electric one; the second furnace was gas-fired. In the latter, the fuel does not come in contact with the work but is passed through tubular muffles. The atmosphere or gas in the furnace which surrounds the work is generated externally and fed into the furnace to prevent oxidation and scaling of the tubing. The furnace operation is continuous, the boiler tubes being fed into one end, passed on through a cooling chamber where they are dropped to a point below the scaling temperature before being discharged.

The tubes are then carried directly into a bluing oven where they are coated with an extremely thin, tightly adherent, blue oxide which is uniformly distributed over the surface. This coating is so thin that it does not flake or peel off and is a distinguishing characteristic of the tubes thus manufactured.

All tubes are straightened after normalizing, and their ends trimmed in a lathe to insure satisfactory rolling. Tubes are hydrostatically tested to a pressure equivalent to approximately 80 per cent of the elastic limit of the steel. This is far above code requirements and is used as a safety precaution. The tubes are under continuous inspection while under test.

Final inspection includes checking for length, gauge, diameter, surface, etc. Flanging, flattening, and crushing tests are made to insure that each lot will conform to specification S-32 of the A.S.M.E. Boiler Code, which covers electric resistance welded boiler tubes. Each tube is then stencilled with the code.

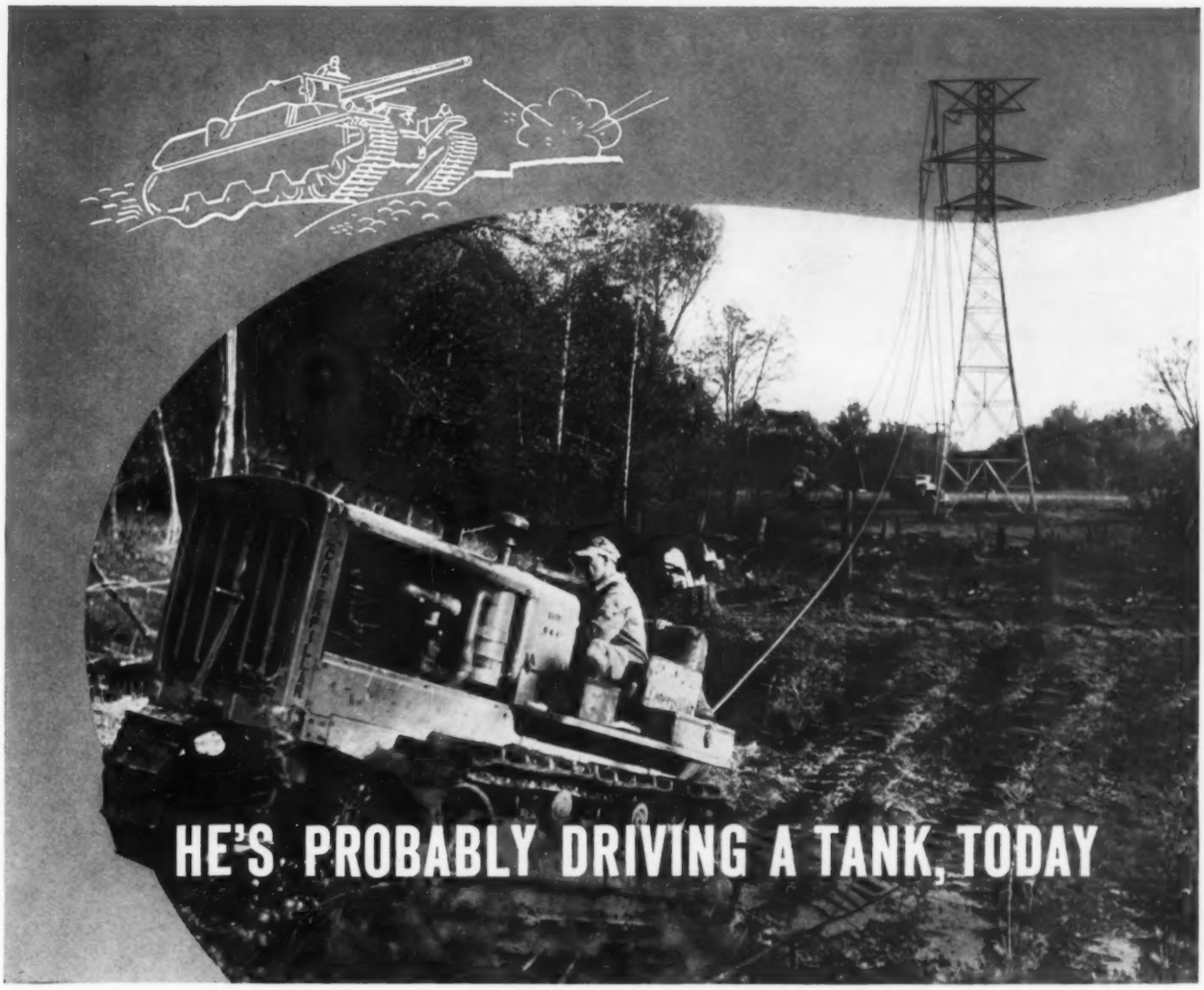
Other well known products made by this process include electrical metallic tubing which is a light wall conduit used with threadless fittings. The tubing is welded by the same process and then electro-galvanized on the outside and enameled on the inside. The large diameter pipe and heavy wall tubing is used extensively in the oil industry and is available both in soft steel and in the higher tensile grades which are made from higher carbon steels.

Still another application of this process is in the manufacture of rail carbon tubing. Rails of a re-rolling grade are heated and then rolled into a flat strip and finally formed into a butted pipe. This butted pipe is allowed to cool, then pickled to remove the scale, and run in cut lengths through a welding machine. The surface is not comparable to tubing produced from ordinary flat-rolled steel, but is excellently adapted for many structural purposes where strength is the important factor, such as in agricultural implements, farm equipment, truck frames, etc.

With the rapid expansion of the war production program, both the applications and the range of grades produced in electric resistance welded pipe and tubing have been considerably increased. Some of the items in which electric welded tubing is used include chemical bomb burster tubes, machine gun mounts, parachute flares, etc. The analyses vary from the standard low carbon, mechanical tube grade to about 0.40 per cent carbon for tubes where higher physical properties are required. Tubes in the latter classification are made to definite physical properties for those structural applications where strength is a vital factor.

The same process is also used in the manufacture of austenitic stainless steel tubing — 18-8-S and its various modifications. These tubes are extensively used in many process industries where corrosion is a serious problem and where resistance to scaling is required. They are also used for aircraft exhaust stacks because of the relatively high temperatures involved.

The most recent development in this process is the manufacture of aircraft tubing from X-4130 steel which is the chrome molybdenum analysis used almost exclusively for structural parts. The earlier statements with regard to strength of weld apply equally to X-4130, and the tests made on this product have proved that it is well adapted to aircraft construction purposes.



No land battleship could be maneuvered more cleverly than the way he handled this cable-stringing "cat." The skill with which he snaked the bull ropes through swamps, up hill and down, speeded erection of this important line. Today, this line is backing him up, carrying power to vital war-production plants.

The Government has ruled that power lines—rural or hi-lines—are to have wire and fittings needed to keep them on the job. Ruling P-46 permits you to obtain the proper materials for their maintenance.

If it's engineering help you're needing, Alcoa engineers are available to give you that, too. Write ALUMINUM COMPANY OF AMERICA, 2128 Gulf Building, Pittsburgh, Pennsylvania.

ALCOA ALUMINUM

A.C.S.R.

A·C·S·R *Aluminum Cable Steel Reinforced*

ON RURAL POWER LINES AND HI-LINES

Adjustable Voltage

SKIP HOIST CONTROL

By F. R. Burt

METAL WORKING SECTION
INDUSTRY ENGINEERING DEPT.
WESTINGHOUSE ELECTRIC & MFG. CO.
EAST PITTSBURGH, PENNA.

▲ THE application of electrical equipment to a blast furnace skip hoist is rather simple as far as the determination of capacity is concerned. The loads, the inclination of the track, the speed and the number of trips per hour are definitely known, and the torque requirements and root-mean-square loads can be easily calculated. However, there are two factors of prime importance in the selection of the type of equipment.

One of these is, of course, reliability, and with this goes low maintenance. A blast furnace skip hoist must maintain its schedule 24 hours a day and 365 days a year for the period during which the furnace is in blast and this may be for several years. Maintenance can be considerably reduced by the use of a variable voltage drive, which does away with all heavy current handling contactors.

Just as important is the matter of smooth, accurate stopping. The mechanical construction of a skip hoist is such that very little overtravel is allowable after the final dumping position is reached. Figure 1 shows the skip in four positions at the top of the furnace. It will be noted that when the front wheels travel into the dumping horns the rear wheels continue up the main track. This results in a transfer of weight and due to this transfer as well as to the fact that the material is flowing out of the skip, the effective rope pull on the top skip decreases to a low value. This may result in the net load on the hoist motor becoming very low or even becoming re-generative.

Typical load curves hoisting ore and coke, which are the heaviest and lightest loads handled, are shown in Figure 2. It will be noted that in hoisting ore the load varies from a torque equivalent from 900 hp positive to a torque equivalent of 165 hp negative, and the cor

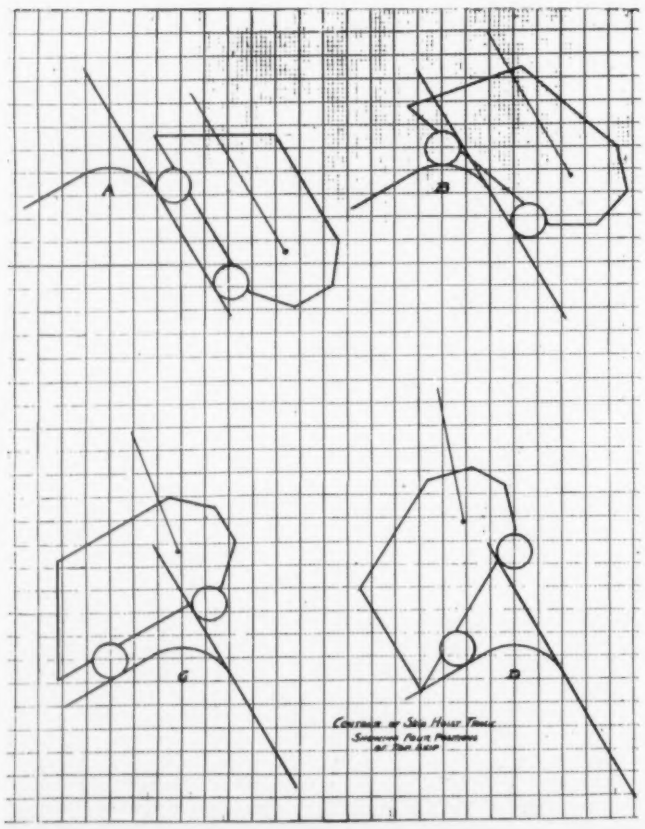
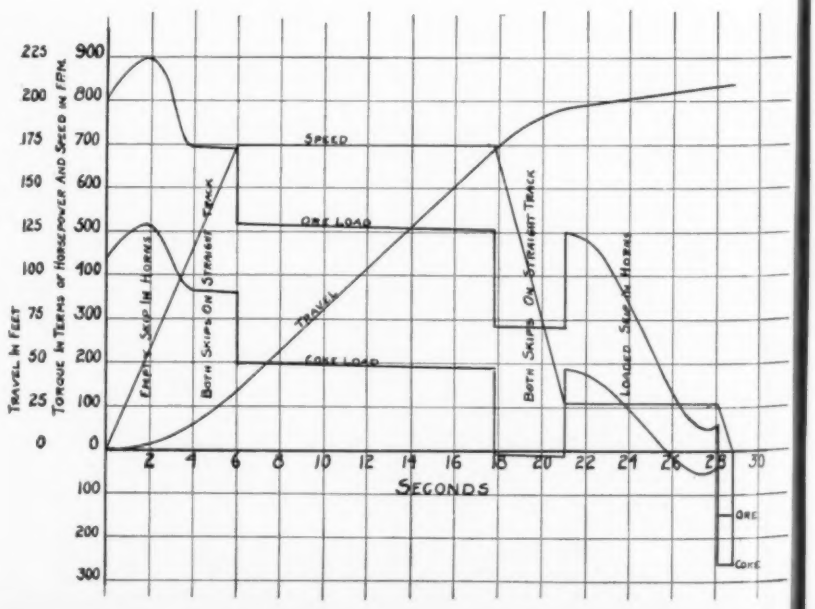


Figure 1 — Contour of skip hoist track showing four positions of top skip.

▲

Figure 2 — Typical load cycle curves for hoisting ore and coke.



...through use of a regulating device on the variable voltage control, blast furnace skip hoist speed is made independent of its load...

responding horsepowers hoisting coke are 520 hp and 260 hp respectively.

The most important part of the cycle is the last 15 or 20 ft. While this comprises only the last 10 per cent of travel in feet, it requires 35 per cent of the total time of a trip. Considerable time can be saved in this portion of the cycle by accurate control of the speed independent of load.

It is required that the speed be reduced in going into the horns and, in order to obtain an accurate stop, it must be at a definite value at the time the final stop is initiated. The speed at this point must be unvarying regardless of whether the skip contains ore or coke. Accurate speed control independent of load means that this speed can be reached at the same point of travel under all conditions and therefore the high speed can be maintained up to the last possible moment.

This condition is very difficult to obtain with the hoist motor supplied from constant voltage, where the slowdown speed must be obtained by means of an armature shunt. In case of a high speed hoist, the slowdown speed may be only 15 per cent of the maximum speed. This means a very heavy aramature shunt, with many times full load current being drawn from the line, and a variation in speed under different load conditions.

With a conventional adjustable voltage hoist drive the required condition can be more nearly met, since the slowdown speed is obtained by reducing the generator voltage to a definite value. However, where this voltage is a small percentage of the full voltage, the speed regulation of the motor is very poor, even though it may be flat at the high speed. This is because the IR drop in the circuit, and the residual voltage, becomes a large percentage of the slowdown voltage.

The improved type of skip hoist adjustable voltage control incorporates a regulating device, known as a Rototrol, which inherently corrects for conditions which cause the motor speed to vary from the value it should have at any generator field. The conventional connections of this regulator are shown in Figures 3 and 4.

Figure 3 shows the armature connections for the main motor and adjustable voltage generator. In series with this main circuit, or across a shunt in the main circuit is one pilot field, while another pilot field is connected to measure the voltage.

Figure 4 shows the connections of the main field of the adjustable voltage generator and the self energizing and pattern fields. These together with the proper resistors are connected in a bridge circuit. The Rototrol thus has three fields — a field in the main armature circuit whose ampere-turns are proportional to the load current of the hoist motor, a field across the main circuit whose ampere-turns are proportional to the

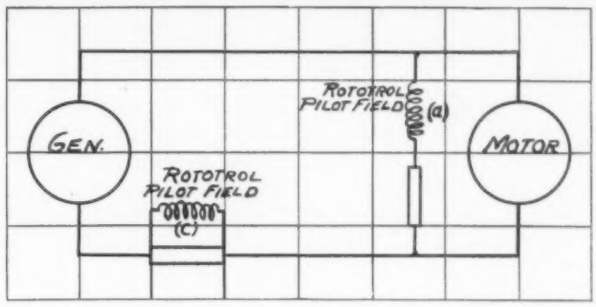


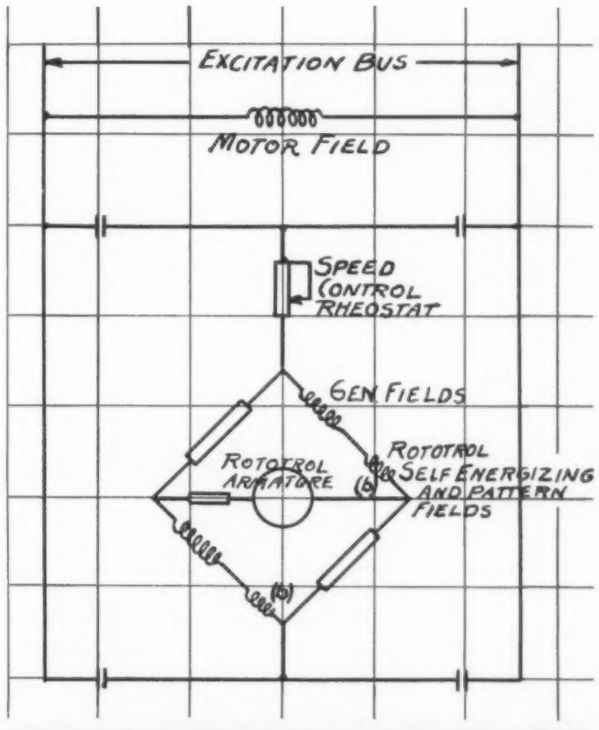
Figure 3 — Armature connections for the main motor and adjustable voltage generator for conventional Rototrol.

voltage across the hoist motor, and a field in series with the main generator field whose ampere-turns are proportional to the main generator field current.

The bridge circuit is balanced so that the current through the main generator field is made up of two components. One is due to the external excitation voltage which can be considered as a component proportional to the proper motor speed and one is due to the regulating device which is a corrective component.

The speed of a separately excited direct current motor varies as its counter electromotive force which is determined by its armature voltage and load current. The fields (a) and (c) measure armature voltage and load current and are proportioned so that at any load condi-

Figure 4 — The main field of the adjustable voltage generator and the self-energizing and pattern fields of the Rototrol.



tion their net strength is equivalent to the motor counter electromotive force.

At no load, field (a) balances out field (b) which results in zero excitation and output of the armature. Under load the motor speed drops and the net strength of fields (a) and (c) is decreased. This action causes the regulator to circulate a corrective component of current through the bridge circuit. This current supplements the excitation of the generator and causes a rise in voltage to compensate for the drop in speed due to increased load. This action continues until the net strength of fields (a) and (c) balances out the component of current in field (b) due to the external excitation voltage. Thus the regulator holds the net strength of fields (a) and (c), motor counter electromotive force, and motor speed at a constant value as determined by the setting of the speed control rheostat.

The Rototrol also compensates the generator excitation for magnetizing effects such as residual voltage and saturation. To obtain the proper motor speed at very low generator voltages where residual is a factor the corrective component may be negative.

This regulator is therefore a means of obtaining practically flat motor speed regulation at any point regardless of load, residual generator voltage, and generator regulation.

The speed of the hoist can be brought down to the same value at the same point in its travel, regardless of load. It follows that maximum use can be made of the time available, since no allowance need be made for the worst condition of load in setting up the limit switches.

It should be noted that the device is only corrective, and is not depended on for the main control of generator voltage. Without it the equipment can be operated as a conventional adjustable voltage drive.

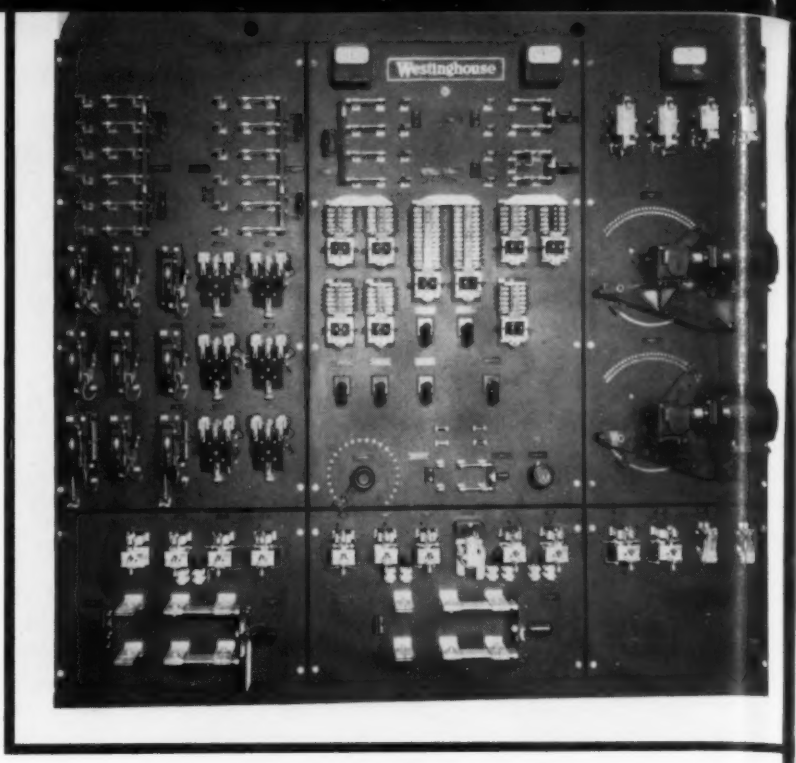


Figure 5 — Control panel for a two motor-two generator variable voltage installation.

OVERALL HEIGHT FOR STANDARDIZED D-C MILL MOTORS

"The Report of the Committee on Revision of A.I.S.E. Standardized D-C Mill Motors" by G. R. Carroll, Chairman, as issued in the August, 1940, issue of the *Iron and Steel Engineer*, pages 54, 55, 56 and 57, and the 1940 Year Book, pages 402, 403, 404 and 405, does not include a reference to the overall height of the motor from base line.

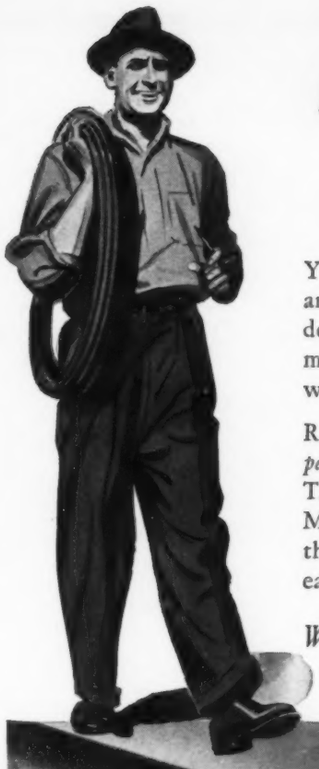
In the discussions of the various motor frame dimensions which should be considered and tabulated as standard, the committee thought that the overall height dimensions was not of particular importance and, as it would have penalized the manufacture of one make of motor materially to comply with the overall height dimensions of the other two makes of motors, it was decided to omit this one dimensions in the standardized list.

It seems advisable to call this matter to the attention of the A.I.S.E. members as they may at times have occasion to consider the subject and, for convenience of comparing the overall height of the three makes of mill motors, they are listed in the accompanying tabulation.

D-C. MILL MOTORS

Overall height, base to highest point of frame

General Electric		Westinghouse		Crocker-Wheeler	
Motor No.	Height, inches	Motor No.	Height, inches	Motor No.	Height, inches
M.D. 402	14 3/4	M.C. 21	14 5/8	S.W. 5	17 3/16
M.D. 403	16 3/8	M.C. 31	17	S.W. 7 1/2	19 5/16
M.D. 404	17 1/4	M.C. 41	17 1/2	S.W. 10	20 1/16
M.D. 406	19 1/4	M.C. 61	19 1/8	S.W. 15	22 1/16
M.D. 408	21 5/8	M.C. 81	21 11/16	S.W. 25	24 11/16
M.D. 410	23 5/8	M.C. 101	23 3/4	S.W. 35	26 9/16
M.D. 412	25 7/8	M.C. 121	26 3/8	S.W. 50	29 1/4
M.D. 414	29 9/16	M.C. 141	29 1/4	S.W. 75	32
M.D. 416	31 15/16	M.C. 161	31 1/2	S.W. 100	34
M.D. 418	35 9/16	M.C. 181	35 5/8	S.W. 150	37 3/4



A Little Rockbestos A.V.C.

GOES A LONG, LONG WAY

You can get MORE out of LESS if you use Rockbestos A.V.C. in places where heat and moisture, corrosive fumes, grease or oil are causing wire failures too often. It does away with shut-downs, production losses and repeated rewiring around boilers, motors, soaking pits, steam lines, furnaces, hot tunnels, kilns, and lehrs because it won't bake out, crack, bloom, flow or rot.

Rockbestos A.V.C. Power Cable, Motor Lead Cable and Boiler Room Wire have *permanent insulation* that stands up in the hot spots under the most severe conditions. They protect your power, control and lighting circuits with *built-in* failure prevention. Make your plans now to crack down on shut-downs by using Rockbestos A.V.C. in the hot spots in your plant. Anticipate your requirements and order now to get the earliest possible delivery.

Write to Rockbestos Products Corporation, 857 Nicoll St., New Haven, Conn.

Built for Steady Service Under Severe Conditions

Rockbestos A.V.C. Power Cable (Underwriters' and National Electrical Code Type AVA) for locations where heat and moisture, oil, grease and corrosive fumes make trouble, has a maximum operating temperature of 110°C. (230°F.) because of these insulation features.*

1. Tough, rugged, impregnated asbestos braid that insures positive protection against heat, flame, moisture, oil, grease and corrosive fumes.

2. Felted asbestos insulation which serves as a heat-seal against high ambient temperatures.

3. High-dielectric, moisture resistant varnished cambric, sealed away from heat, flame and oxidation between two felted asbestos walls.

4. Inner felted asbestos wall which is unaffected by conductor-heating overloads and doesn't burn even when exposed to copper-melting arcs.

*This type of construction also used in Boiler Room or Lighting Wire, Motor Lead Cable, Control Cable and other Rockbestos A.V.C. constructions.

When ordering Rockbestos A.V.C. for hot-spot wiring, don't forget to furnish preference rating papers and give your end-use classification — saves correspondence and gets the wire to you faster.

ROCKBESTOS

ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

NEW YORK BUFFALO CLEVELAND CHICAGO PITTSBURGH ST. LOUIS SAN FRANCISCO PORTLAND, ORE. SEATTLE

A New Hammered Resistance
WELDING PROCESS

...welding by a combination of electric heat and a hammering action, this process produces a good weld without flash or fin, with low power consumption...

By A. L. Pfeil, President

UNIVERSAL POWER CORP.

CLEVELAND, OHIO

Presented before A. I. S. E.
CLEVELAND AND YOUNGSTOWN SECTIONS

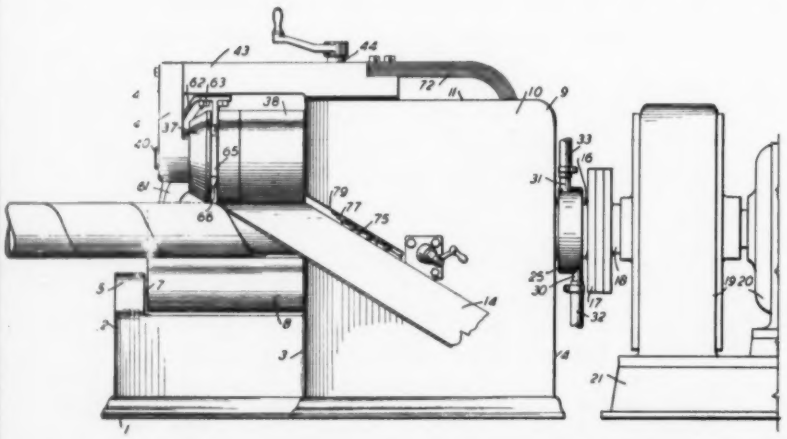
▲ SEVERAL years ago the fertile genius of the inventive steel and electrical engineering minds initiated the use of the "resistance" welding processes; better known by their specific names, "spot," "butt," "flash," and "seam" welding. More recently there has been developed a resistance welding process in which electrical current is used to supply heat at the edges to be welded while, as in the blacksmith weld of old, a hammering operation is simultaneously carried on directly at the weld heat point. This development grew out of a machine that was specifically designed to make spirally wound narrow strip into fluid-tight welded pipe or culvert of fairly large diameters.

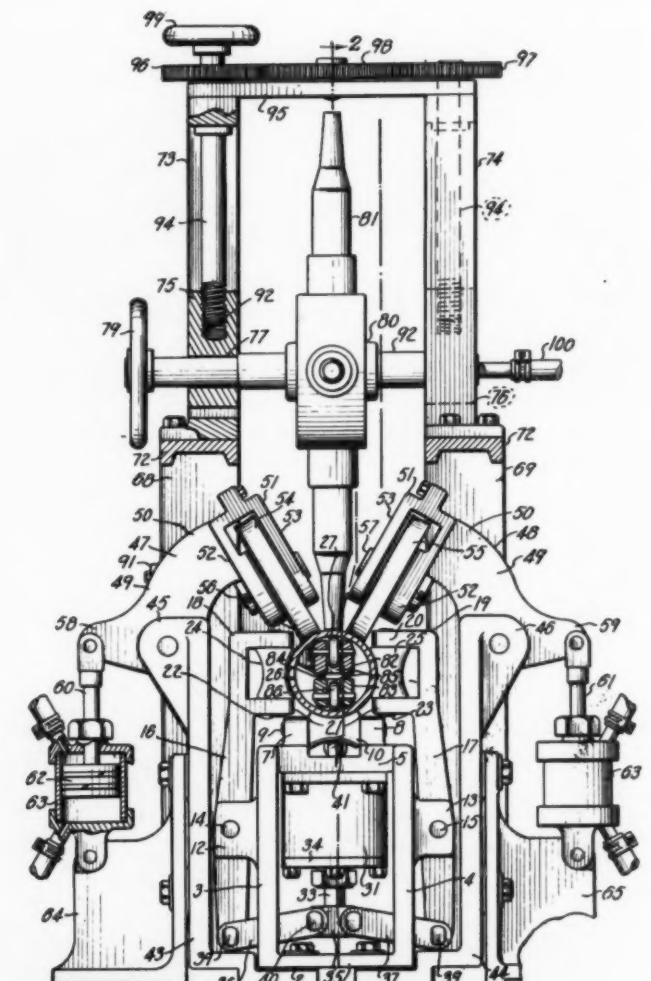
It is scarcely necessary to enter into a discussion of the fundamentals involved in the resistance welding processes. Yet, to start at the beginning, a brief review of the basic facts involved will serve to make more understandable the merit of the "hammered resistance" weld that is to be here presented.

In essence in resistance welding, we usually have a•

Figure 1 — Original spiral pipe welder making hammered resistance welded joints. (below)

Figure 2 — Tube butt welder making hammered resistance joint. (right)





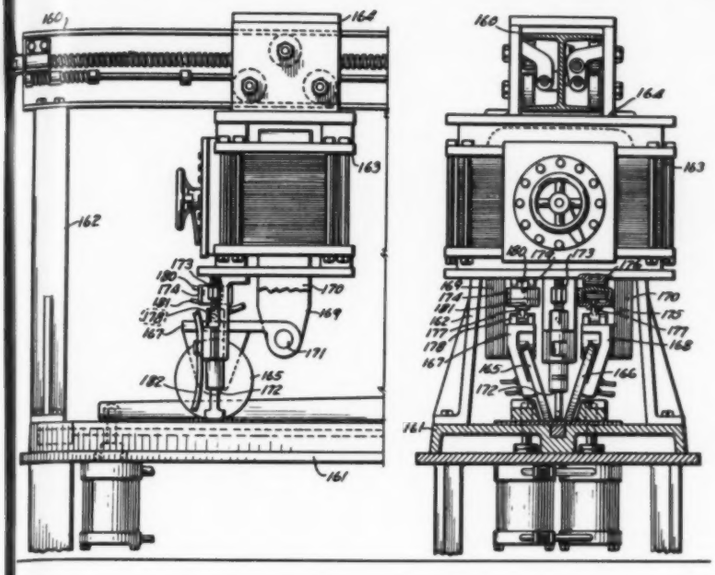


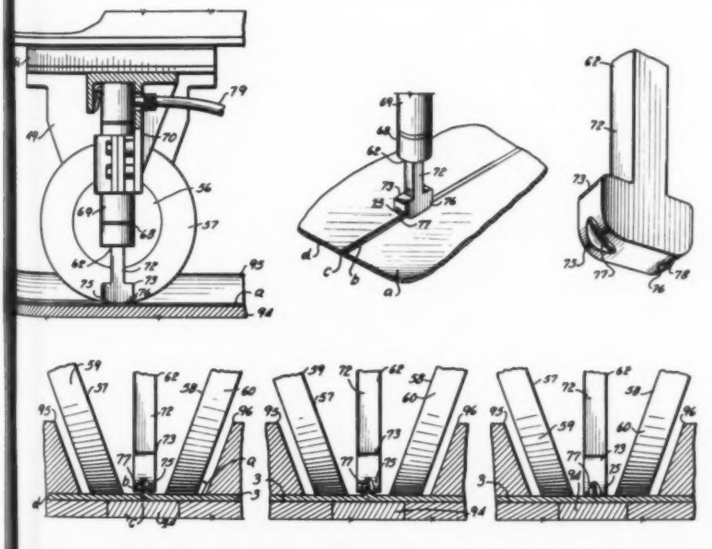
Figure 3 — Flat strip welding machine showing location of hammer.

single phase power supply voltage fed into a transformer primary winding which supplies the welding energy in the form needed to another, or secondary, winding that is put on the same transformer core to deliver a very high current ranging from 3000 amp to 1,000,000 amp at from two to roughly twelve volts — sometimes more.

The most used and best known resistance welding process is simple spot welding in which a heavy current is put through small points at "un-ethically" high current densities to confine current flowing into as relatively small an area as possible through the two steel pieces to be welded. It is to be noted that in spot welding the place where we want our heat to be most intense is the small area between the surfaces of the metals to be joined. We therefore use copper alloy points which, in addition to being good electrical conductors, are excellent conductors of heat — many times better than iron or steel. Thus, these points when internally cooled by water or refrigerants, stay relatively cool and tend to keep the steel surfaces they pressure contact relatively cool also, so that as much as possible the heating is confined to creating between the surfaces to be welded a molten globule which, after the heating current is cut off, with pressure still sustained, is cooled into a small nugget-like casting, uniting the two pieces. There should be no fireworks in the spot weld process when properly used — the best welds occurring under correctly predetermined conditions of current time and to some degree pressure, and to a large degree cleanliness of surfaces to be welded.

In conventional seam welding of the overlapped joint type, spot welding technique is followed using either a

Figure 4 — Showing one form of plate edge preparation suited to lighter gauges.



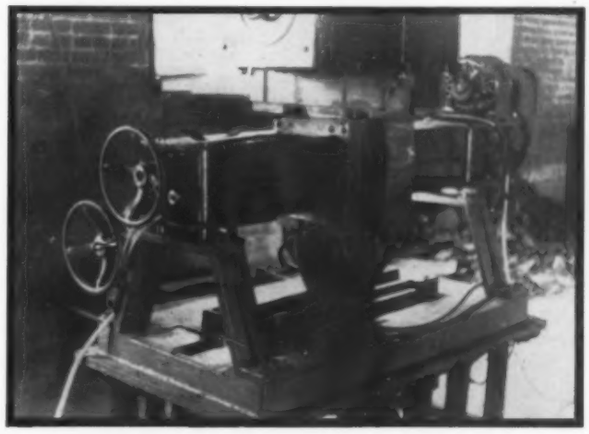


Figure 5 — Experimental light plate welder.

series of overlapping spots or sometimes also a continuous and uninterrupted current flow. The latter may be used where the pieces to be welded are moved relative to the roller contacts at speeds suiting the heating current settings.

In butt seam welds such as in the making of welded steel tube under the several patented processes now available the usual procedure is to form the tube in such a way that the abutting edges are caused to be pressed into electrical contact at the place where the current feeding rollers are located, forcing fusion to occur under conditions which differ somewhat from the spot weld and lap seam weld above, because the edges while at a plastic temperature are squeezed up into a pressure forging type of joint. In some such welds the extra metal pushed up is allowed to form as an outside bead which is later removed by a planing, grinding, cutting, or scarfing operation. In some such welds the

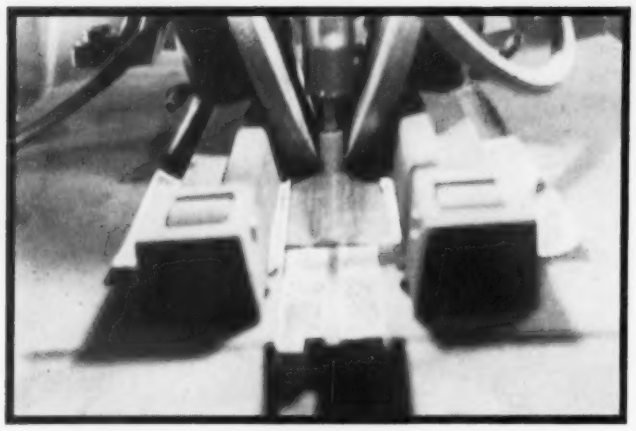


Figure 6 — View of plate as welding progresses.

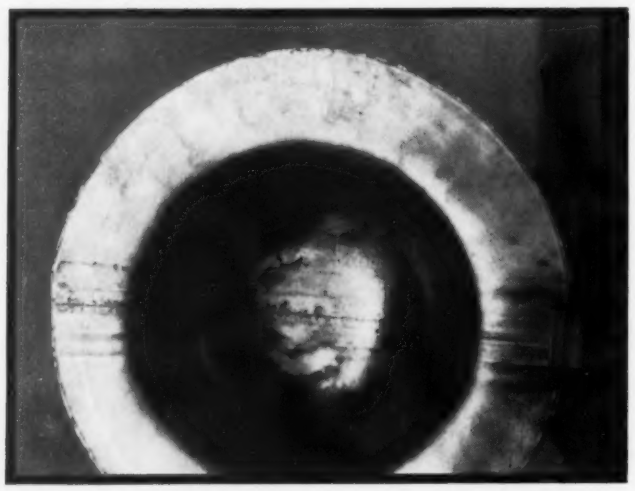


Figure 7 — Dished steel plate showing ductility of welded joint.

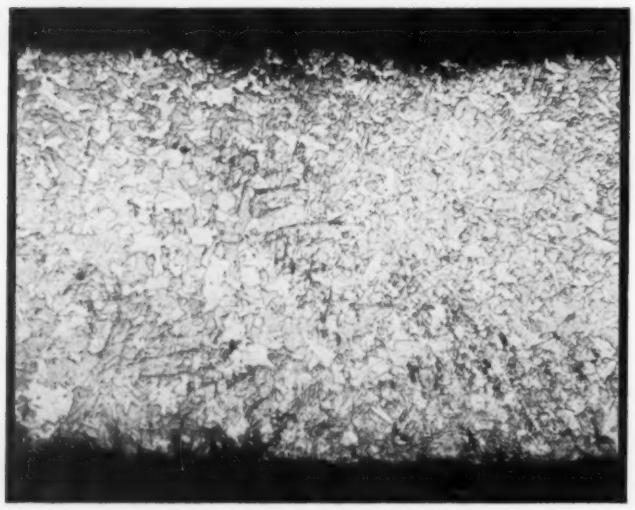


Figure 8 — Microphoto of 18 gauge plate welded by hammered resistance weld process showing weld joint.

heated metal is completely confined by rolls or dies, so that no flash or excess metal is formed.

In edge welding, or flash welding of flat or formed sheet, or butt welding of bar stock, a somewhat different action occurs than in spot welding — consisting of a consecutive series of contact surface arcs, — inevitable because of largeness of area of abutting pieces, — which form as the edges are brought against each other. The heat so generated makes the contacting edges plastic or molten after which the edges are pushed together and the burned metal squeezed out into a flash or fin to permit the molten metal back of the edges to be formed into a good joint. Thereafter the flash is knifed or ground off, leaving the joint of about the same thickness as the original plate.

This flash welding operation is that used on the strip mill welders with which most steel men are familiar — where one hot strip steel roll end is joined to the one following it to keep a continuous piece going through the pickling tanks prior to other finishing or cold rolling operations.

The hammered resistance weld is a combination of the tube butt weld and edge flash weld procedure above outlined, except that no flash or fin is created and no fireworks take place because the welds are of a progressing continuous time type.

Originally the process was conceived to make steel spiral wound large diameter relatively thin wall pipe made from narrow strip. The same idea was then tried on straight seam welded formed steel tubing and more recently on butt welding flat strips edge to edge to simulate the requirements of a strip mill welder.

In simplest terms, the welder consists of a pair of current feeding rollers or shoes in contact with the top surface of the two pieces to be joined and an air operated or electrically operated hammer between these rolls and above the edges to be joined — the purpose of the hammer between these rolls and above the edges being to bring the edges together and to create a rapid hammering forging action on the joint as it is heated and fused together and after welding during the cooling cycle if desired. In other words, it is the old blacksmith's weld made with electric edge contact resistance heating means.

As to advantages of this process over others, the greatest contrast is to be found in comparing this method of joining edges to the flash weld process.

1. Electrical kva input or demand required is about one-fifth that required for flash welding to do the same job in the same time.
2. The cost and mass of the apparatus is conservatively about one-third that of flash weld apparatus to do the work.
3. The weld metal joint produced is at least equal to that of the flash weld and may be controlled as to finished thickness and hot or cold forging action.
4. No metal is heated that has to be cut off and thrown away, i.e. no flash or fin — thus eliminating need for an extra operation.

In these days when use of central station power supply systems is to be conserved by keeping demand charges and surges at a minimum, this process has something to offer for the making of war munitions.

Figure 9 — Microphoto showing fusion zone at 250 diameters magnification.

Compared to conventional welded tube mechanisms the mass of the apparatus and its cost may be considerably less since instead of heavy continuous high pressure rolls, the intermittent impact action of the hammer blows means that the same effect may be attained with lighter apparatus. No data is available as to comparative power consumption of the conventional tube butt weld as against the hammered weld; it is felt that because of the intermittent hammer blows edge contact resistance is higher at the weld with consequent lower current called for to produce needed heat.

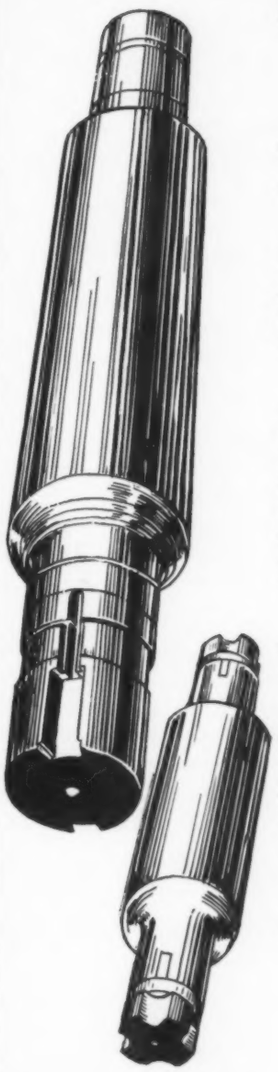
In the hammered resistance weld the metal, during the actual welding properly controlled, shows no sparking while the hammering action joins the sheets. The heated metal, immediately following the hammer, has a dull dark red color.

Typical pull tests on uniform section coupons welded by this method showed that mild steel of 50,500 psi tensile strength broke outside the weld zone at 50,600 to 51,200 psi. Hardness tests show the as-welded metal in the weld zone harder than the original plate where no annealing rolls are used.

For example, where the plate showed Rockwell B hardness of 45 the welded zone itself showed 65 Rockwell B. At the roller contact points, where the current entered the plate, and where roll pressure exerted a cold working effect, the unwelded plate showed a hardness of 68. This weld zone hardness can be controlled by after-heating rolls or other annealing means if desired.

As to the metal structure in the fusion zone, metallurgically, the steel became molten, or approached the melting point to permit actual welding of the separate pieces of steel strip. The microstructure as welded shows a tendency towards the Widmanstatten type structure commonly associated with cast structures.

NATIONAL ROLLS



Roll Formulas for Specific Tasks

VERY often a type of roll will perform unusually well in one mill with only normal performance in another, and in such cases we look for the reason.

It is often found, and usually calls for special treatment in the future to meet the unique condition encountered, and thus each roll is fitted closely to its specific work and the practices of the mill itself.

NATIONAL ROLLS represent the highest operating efficiency for the tasks for which they are made that we can build into them — from the conclusions constantly derived from causes, effects, trials and errors.

H. H. Seamon

President and General Manager

THE NATIONAL ROLL & FOUNDRY CO.

Rolls & Rolling Mill Equipment

AVONMORE, PA.

Production of BENZOL PRODUCTS by the CONTINUOUS Process

By C. R. Lohrey

GENERAL FOREMAN, BY-PRODUCTS

GREAT LAKES STEEL CORP.

ECORSE, MICHIGAN

Presented before A. I. S. E. DETROIT SECTION, November 11, 1941

...a description of plant and operation for the recovery of light oil products by the continuous fractionating process...

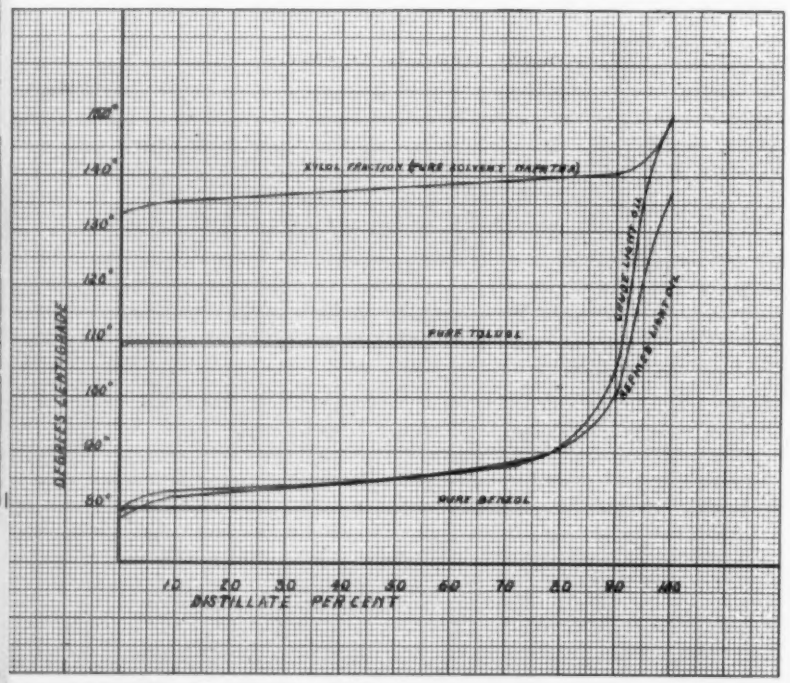
▲ THE present national defense program has greatly increased the demand for coke oven by-products of high quality. Among the more important of these by-products are pure benzol, pure toluol and xylol; all of which are being produced at the Great Lakes Steel Company coke plant in quantities totaling approximately 3,500,000 gallons per year.

The plant for the refining of these materials from coke oven light oil is described as a continuous fractionating process as compared with the usual batch process commonly used in the coke industry. It is the purpose of this paper to describe somewhat in detail the operation of this plant and to offer data showing the results thus far obtained.

The benzol plant covers a space of approximately 135 ft by 150 ft which is entirely fenced off from the rest of the coke plant. In this area are buried within a concrete retaining wall, fourteen storage tanks, each having a 16,000 gal capacity. Five of these tanks store finished pure products while the remainder are used for crude or semi-processed material. One storage tank for sulphuric acid and another for caustic soda are above ground. The four still columns are located in a compact group just outside the benzol building along with three reboilers used in the operation of these columns. The benzol building proper is a two story brick structure 30 ft wide by 46 ft long. On the ground floor are located the feed pumps for the still columns, the pumps for loading tank cars and pumps used for other miscellaneous pumping operations. The second floor of this building is the operating floor. All the important indicating and recording thermometers, pressure gauges, flow meters, as well as all the control valves for the stills are mounted in this area; the product receiver tanks and distillate pumps are also located on this floor. The condensers and after-coolers are located on the roof above the operating floor. As part of this same building but separated from it by a fire wall and fire door is an 18 ft by 30 ft three story brick lean-to, housing the two acid washers and the auxilliary equipment for the operation of these acid washers. Two pairs of tracks along one side of the building and tank farm provide the means for placing tank cars for cleaning and loading for shipment. A small 6 ft by 8 ft metal building, on the same level as the operating floor and approximately 15 ft from the main building, is fitted with the necessary equipment for making all the physical and chemical tests required to guide the operation of the plant. Vents from storage tanks and other equipment are protected by flame arrestors of approved design. A sprinkler system throughout the building provides protection against destruction by fire.

It should be mentioned at this time that the quality of the crude light oil processed has varied from time to time due to changes in operating conditions at the ovens. Various coals and coal mixtures have been used with concentration of low volatile coal ranging from 15 to 35 per cent. Coking times have ranged between 15½ and 37 hr and both blast furnace gas and coke oven gas have been used as underfiring fuel for the ovens. The data presented here showing the quality of products produced includes the periods of extreme vari-

Figure 1 — Chart showing distillation curves for by-products of the coking process.



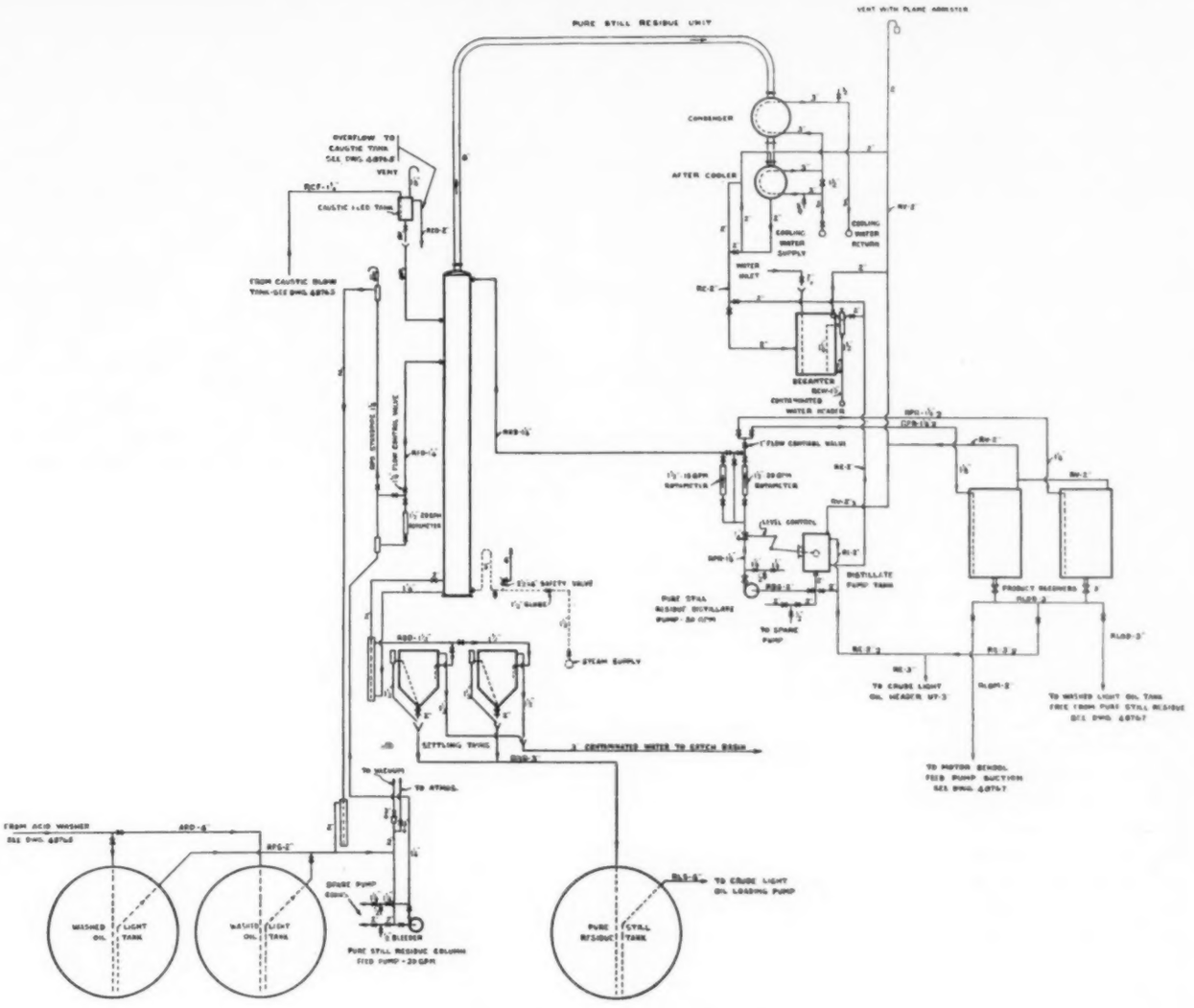


Figure 2 — Flow sheet of residue removal column.

ation from normal as well as periods of normal operating conditions.

All chemical and physical tests are carried out according to Barrett's methods of procedure which are considered as standard for the industry.

Acid Washing

The light oil as delivered to the benzol plant for processing has a distillation range as indicated on the curve in Figure 1; it contains in addition to benzol, toluol and the xylol fraction, such impurities as forerunnings, (or low boiling material), paraffin, hydrogen sulphide, sulphur dioxide, thioephene, traces of other complex sulphur compounds and olefines or unsaturated oils. The amounts of these impurities vary with changes in operation at the ovens, such as coal mixtures, coking temperatures, etc.

The initial treatment of the oil in this process, namely acid-washing, is practically the same as that given in many plants producing pure products by the batch process, and is likewise a batch treatment. It is carried out in two acid washers or agitators which are upright cylindrical tanks with conical bottoms into each of which is fitted a shaft and propeller for stirring. Approximately 5300 gal of crude light oil are charged into each washer and three separate successive washings are given using 66 degree Baume sulphuric acid as the washing agent. This is followed by one washing with caustic soda solution to neutralize any remaining acid in the oil. A period for settling and draining of sludge is allowed between each wash. After the last acid washing a sample of the acid treated oil is withdrawn and tested to make certain the proper results have been attained; also after the caustic soda treatment a second sample is taken and a test is made to be sure that all traces of acid have been neutralized. In the first test a small amount of the oil is distilled in the laboratory and the standard Barrett wash test run on a portion of the distillate. The second test is simply mixing the

sample with methyl orange indicator to determine the absence of acid.

This acid washing treatment must be carried out very carefully to insure high quality pure products from the balance of the refining process inasmuch as there are impurities present in the crude oil which if not removed at this point cannot be eliminated in any other part of the process following this treatment. Provision is made, however, for neutralizing traces of acid in the oil should the caustic soda washing, through error or neglect, not have been adequate in the procedure just described, but it is not so provided in case the acid treatments have not been carried out properly.

The acid sludge is drained into an open top ladle, hauled to a pit located at some distance from the plant, dumped and burned. The treated oil is drained into storage tanks where it is held until a sufficient amount is accumulated to insure a continuous and constant flow through the fractionating columns.

Residue Removal Column Unit No. 1

The acid and caustic treatment has eliminated the major portion of the unsaturated oils. However, the light oil still contains the following impurities: forerunnings, paraffins, traces of sulphur compounds and some polymerized material still in solution in the oil. The first still column through which the oil is passed (unit No. 1) is called the residue removal column, whose function it is to separate this polymerized material from the oil as a residue from the base of the column and recover the remaining material as the distillate. This distillate is termed residue free oil or refined light oil. This unit is operated as follows: a centrifugal pump delivers a constant flow of washed light oil through a metering tube (which indicates the rate of flow) into the still column at a point somewhat above the middle. Live steam is introduced at the base of the column at a controlled rate sufficient to vaporize all the light oil except this polymerized material or residue. This residue along with condensed steam flows from the base of the still into a conical bottomed tank where the residue settles to the bottom and is drained to a storage tank while the water is drawn off into a contaminated water catch basin. A two-pen recording thermometer shows the operator the temperature of the vapors leaving the top of the still and the temperature of the mixture near the bottom of the column. A mercury manometer indicates the pressure at the base of the column. Hourly samples of the distillate are analysed in the control laboratory adjacent to the operating floor to determine the acid wash test, the dry-point by distillation, and the absence of acid by reaction to methyl orange indicator. This still column is provided with means of continuously adding a small amount of caustic soda solution to the feed should the distillate show an acid reaction to methyl orange. (It should be mentioned this is rarely necessary.) The distillate, refined light oil, passes through a decanter where the water separates by gravity, the oil being pumped to receiver tanks from which it is drained after testing, to a storage tank or fed to the next still column. Our practice has been to drain to the storage tank in order to equalize any temporary variations in product quality. The piping is so arranged that a portion of the distillate can be pumped through a metering tube or flow indicator to the top of the still column as reflux. The operator can resort to this means of maintaining the still in balance in case of irregularities such as temperature or pressure of the steam supply, etc. It is apparent that sufficient steam must be introduced to completely vaporize all material having a boiling point of the xylol fraction or under and yet not cause any of this polymerized material to carry over with the vapor. To maintain such a condition the operator closely watches the results of the periodic distillation tests, the temperature at bottom and top of the column, the pressure in the column and the appearance of the residue and distillate. Any changes noted from the preceding set of observations indicates to him the necessity of making certain changes in order to maintain good operation.

It should be mentioned that the operation of this column and likewise of the entire distillation process is hand controlled. This is feasible because the limited amount of space into which all the control points have been located is readily accessible to the operator from his post on the operating floor.

Typical operating data for this column is shown in Table I.

Unit No. 2 — Motor Benzol Column

Having removed the unsaturated oils, any impurities now remaining in the oil can only be removed if their boiling points are sufficiently different from those of benzol, toluol and xylol to allow separation by fractional distillation within the limits of the still column efficiency.

As originally planned, the second unit in our process, as its name implies, produced motor benzol. In order to make this material of proper quality, particularly as to the specification limits for initial boiling point and sulphur content, it was necessary to divert from 35 to 50 per cent of the total benzol content of the oil into motor fuel, the amount depending upon the quality of the light oil being processed. As we now operate, however, this No. 2 column is used as a forerunnings column and removes only material with a boiling point lower than that of pure benzol. This means that by so

TABLE I

Residue Removal Column — Unit No. 1

Feed — gal per hr	696
Reflux — gal per hr	—
Product — gal per hr	683
Reflux ratio	—
Top temperature	73 C
Bottom temperature	101 C
Still pressure, psi	1.3
Temperature of distillate	20 C

Product

Acid wash test	0+
Alkalinity	O.K.
Distillation dry point	137 C

operating, 100 per cent of the benzol content of the oil is produced as pure benzol.

This unit and the two subsequent units in the process consists of a reboiler into which are fitted steam coils for the necessary heat supply, a fractionating column, condenser, after-cooler, feed pump, product pump and the necessary gauges, thermometers, etc. Figure 3 shows a diagrammatic arrangement of the equipment and piping.

There are three levels on this column at which the feed can be introduced. As a forerunnings column we have found that better results are obtained by feeding at the uppermost point. Normally the rate of feed of refined light oil to this column is approximately 675 gallons per hour. By using a very high reflux ratio with a product take-off of approximately 2 per cent of the feed, we are able to strip out all the forerunnings contained in the oil along with a small amount of benzol. This two per cent take-off portion is collected in a storage tank until this tank is full which normally requires about three months time. Then during a period when the benzol plant is down, by re-running this material through this same column, (unit No. 2) at a slightly lower rate, usually about 600 gallons per hour, the forerunnings are separated as a distillate which is fed into the blast furnace gas main to the ovens. The benzol contained in this two per cent forerunnings fraction is removed from the bottom of the reboiler as a liquid, through a cooler into a storage tank from which it is loaded into tank cars for shipment as pure benzol. About 24 hours are required to complete each of these tri-monthly reruns.

As a guide for the usual operation of this second unit, distillation tests and periodic observations of temperature, pressure, etc. throughout the unit are recorded. The data in Table II shows a typical set of conditions

TABLE II

Motor Benzol Column — Unit No. 2

Feed — gal per hr	672
Reflux — gal per hr	630
Product — gal per hr	14
Reflux ratio	45
Top temperature	75 C
Middle temperature	88 C
Bottom temperature	92 C
Temperature of distillate	20 C
Still column pressure, psi	4.3
Steam pressure to coils, psi	8
Bottom ring test	81.3 C
Distillation tests:	
First drop (initial boiling)	60.5 C
Dry point	79.5 C
Range	19 C
Acid wash test	1

Figure 3 — Flow sheet of motor benzol, pure benzol and pure toluol columns.

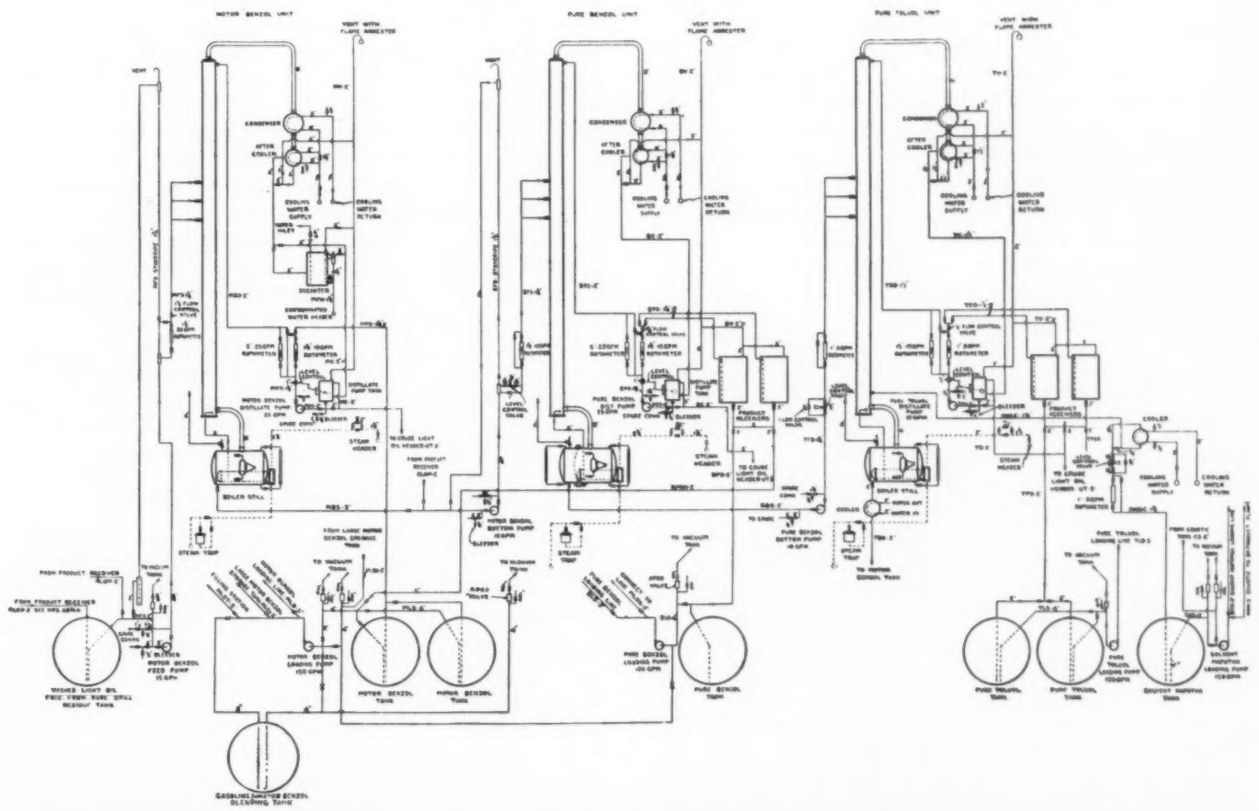


TABLE III

Pure Benzol Column — Unit No. 3

Feed — gal per hr	660
Reflux — gal per hr	630
Product — gal per hr	530
Reflux ratio	1.19
Top temperature	79 C
Middle temperature	95 C
Bottom temperature	124 C
Temperature of distillate	20 C
Still column pressure, psi	4.8
Steam pressure to coils, psi	80
Bottom ring test	111.5 C
Distillation test:	
First drop (initial boiling)	79.7 C
Dry point	80.0 C
Range	0.3 C
Acid wash test	0

Analysis of Pure Benzol

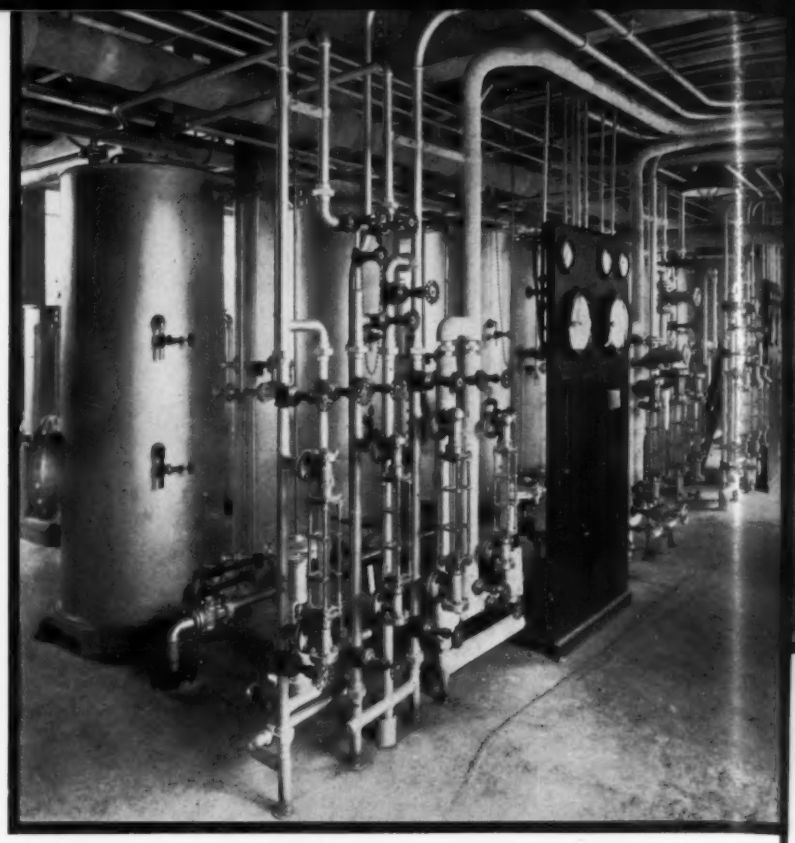
(Yearly average)

Distillation range	0.27 C
Acid wash test	0
Copper corrosion	0
Freezing point	5.54 C
Bromine index	6
Sp. gr. at 15.5 C	0.8835

for maintaining the proper balance of operation. The so-called bottom ring test is the name given the initial boiling point or first drop in a distillation test on the material in the reboiler. This test along with the periodic distillation tests run on the distillate are perhaps the best indication that the unit is performing in the proper manner. The top temperature is the temperature of the vapors leaving the column; the temperature of the mixture at a point about one-fourth the distance up the column we choose to call the middle temperature, and the bottom temperature, of course, is that of the mixture at the base of the column. A record of all three temperatures is made continuously on a three-pen recording chart.

Pure Benzol Column — Unit No. 3

Having disposed of the forerunnings as an impurity, the oil mixture is fed from the base of the motor benzol reboiler through a pump to the middle feed point of unit No. 3, the pure benzol column. Periodic observations and tests similar to those made on the motor benzol column are recorded for this unit also. The operation of this unit is likewise similar to that of the motor benzol unit. At this point, however, care must be exercised to insure the removal of all and only the benzol as the distillate from the oil mixture and leave all of the toluol and higher boiling fractions in the reboiler. It is obvious that any benzol remaining in the oil mixture would distill off with the toluol in the next column and would, of course, produce a material of inferior quality. Likewise should any toluol be allowed to distill off in this No. 3 unit, the product would not



Operating floor of benzol plant, showing receivers for the benzol products.

meet pure benzol specifications. The most simple means of maintaining this unit in balance we find is to maintain, within rather narrow limits, a constant specified middle temperature in the column. If this temperature goes up, we know under normal conditions that too much benzol is being taken off as a product; if this middle temperature goes down, too little benzol is being taken off. In either case the rate of take-off is adjusted accordingly. Another indication that all the benzol has been removed from the oil is the bottom ring distillation test on the reboiler; the presence of benzol is indicated when this test shows too low a figure. As shown in the flow diagram in Figure 3, the pure benzol is pumped to receiver tanks and, after testing, drained to a storage tank from which it is loaded into tank cars for shipment. The material that collects in the reboiler of this unit contains the pure toluol, the xylol fraction and any other product with a boiling point higher than that of pure benzol and is called benzol-free oil.

Pure Toluol Column — Unit No. 4

Although there is approximately 30 degrees Centigrade difference between the boiling points of pure benzol and pure toluol we have in our operations, thus far, never found any intermediate material between these two boiling points, or at least, not enough of such material, if present at all, to contaminate the products to the extent of inferior quality. If such intermediate products were present it would be necessary to remove them in a separate distillation unit which would be located between our pure benzol unit and pure toluol unit. However, since the necessity of such a unit has not appeared, we feed the benzol-free oil from the

General view of the benzol plant, showing fractionating columns, and storage and running tanks.

bottom of No. 3 reboiler through a pump to the middle feed point of unit No. 4, the toluol column.

The operation of this unit differs only slightly from that of the pure benzol unit. The middle temperature here again is used as a guide in maintaining the proper balance for the production of pure toluol as the distillate. This product is collected in receiver tanks and after testing is drained to storage tanks where it is held until ready for shipment in tank cars.

Xylol is a side cut product from this unit and is drawn off as a liquid from a tray near the bottom of the still column. It flows by gravity through a product cooler, then through a metering tube, which indicates the rate of flow, and directly to a storage tank. Changes in the bottom temperature in the column give some indication of changes in conditions at the xylol draw-off point and hence indicate changes in the quality of the product at that point. However, the periodic distillation and acid wash tests that are run on samples of this product are the better means of determining proper operation. If a test shows the initial boiling point of the sample dropping below the temperature set up as an operating mark, the rate of xylol take-off is decreased and conversely, the rate is increased if the test shows that the opposite condition prevails. Any product with a boiling point above that of pure solvent naphtha, that was originally present in the product from No. 1 unit (refined light oil) accumulates in the reboiler of this pure toluol unit and is drained off from time to time into a storage tank. Table IV shows typical conditions for normal operation.

This entire description thus far, particularly as to the operating data and quality of products made has been presented on the basis of normal operation. By that, we mean the processing of light oil of the quality produced under normal operating conditions at the ovens. To show the quality of products made under conditions other than normal, an average analysis of each product has been compiled by considering each abnormal period of operation experienced up to the present time. The coking rate during these periods has varied from 24 hr to 37 hr. Table V shows the average analysis of products made during these periods.

The only effect on the operation of the benzol plant during these abnormal periods is a change in the quantities involved. Adjustments are usually made in the quantities of acid used for acid washing, the rates of feed to the still columns are usually lowered slightly and the proportions of product take-off from each unit are adjusted to correspond to the composition of light oil being processed. Other than making such changes, we have experienced no difficulties in operation while processing a light oil of inferior quality.

We believe that in general the operation of this plant up to the present time has been quite successful, as evidenced by the quality of the products made. We also feel that the possibilities for improvement have not been exhausted; several ideas now in mind will be tried as soon as convenient.

TABLE IV

Pure Toluol Column Unit No. 4

Feed — gal per hr		130
Reflux — gal per hr		300
Product — gal per hr, toluol		95
Product — gal per hr, solvent		27
Reflux ratio		3.15
Top temperature		110 C
Middle temperature		122 C
Bottom temperature		150 C
Temperature of distillate		20 C
Still pressure, psi		3.9
Steam pressure to coils, psi		135.0
Distillation test:	Toluol	Solvent
First drop (initial boiling)	109.5 C	133 C
Dry point	110.0 C	151 C
Range	0.5 C	18 C
Acid wash test	0	5

Analysis of Pure Toluol

(Yearly average)

Distillation range	0.41
Acid wash test	0+
Copper corrosion	0+
Sp. gr. at 15.5 C	.8704

Analysis of Xylol

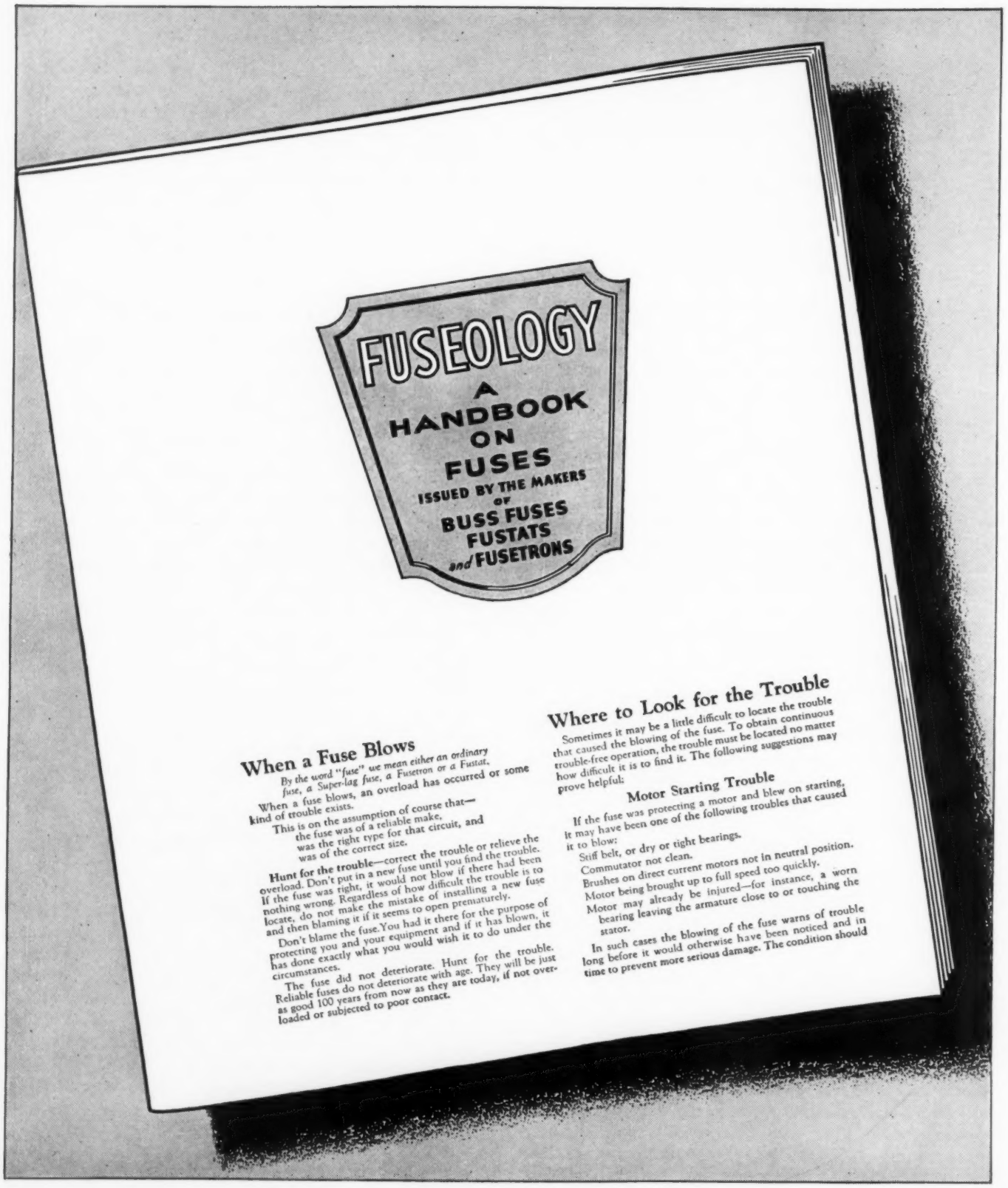
(Yearly average)

Distillation:	
First drop	133.0 C
5 per cent	135.0 C
90 per cent	142.5 C
Dry point	151.0 C
Acid wash test	5+
Sp. gr. at 15.5 C	0.8687
Paraffins, per cent	0.3

(*Please turn to page 54*)

GET MORE "MILEAGE"

This Free *Book Shows how to*



When a Fuse Blows

By the word "fuse" we mean either an ordinary fuse, a Super-lag fuse, a Fusetron or a Fustat.

When a fuse blows, an overload has occurred or some kind of trouble exists.

This is on the assumption of course that—
the fuse was of a reliable make,
was the right type for that circuit, and
was of the correct size.

Hunt for the trouble—correct the trouble or relieve the overload. Don't put in a new fuse until you find the trouble. If the fuse was right, it would not blow if there had been nothing wrong. Regardless of how difficult the trouble is to locate, do not make the mistake of installing a new fuse and then blaming it if it seems to open prematurely.

Don't blame the fuse. You had it there for the purpose of protecting you and your equipment and if it has blown, it has done exactly what you would wish it to do under the circumstances.

The fuse did not deteriorate. Hunt for the trouble. Reliable fuses do not deteriorate with age. They will be just as good 100 years from now as they are today, if not overloaded or subjected to poor contact.

Where to Look for the Trouble

Sometimes it may be a little difficult to locate the trouble that caused the blowing of the fuse. To obtain continuous trouble-free operation, the trouble must be located no matter how difficult it is to find it. The following suggestions may prove helpful:

Motor Starting Trouble

If the fuse was protecting a motor and blew on starting, it may have been one of the following troubles that caused it to blow:

Stiff belt, or dry or tight bearings.
Commutator not clean.
Brushes on direct current motors not in neutral position.
Motor being brought up to full speed too quickly.
Motor may already be injured—for instance, a worn bearing leaving the armature close to or touching the stator.

In such cases the blowing of the fuse warns of trouble long before it would otherwise have been noticed and in time to prevent more serious damage. The condition should

OUT OF YOUR FUSES

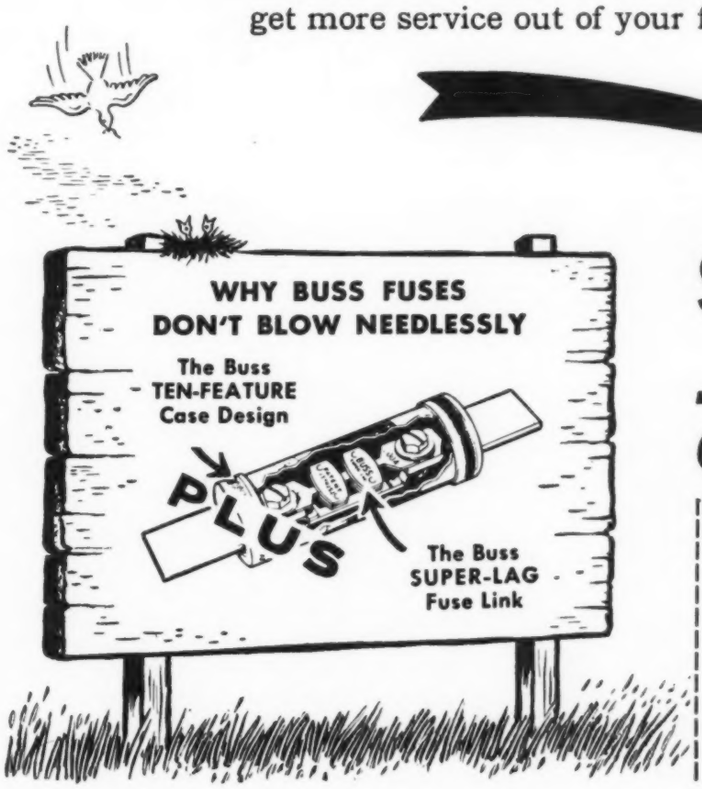
Reduce Electrical Outages . . .

PARTIAL LIST OF CONTENTS

- What to do when fuses blow
- Where to look for trouble that caused fuses to blow
- What to do after you have found the trouble
- How to select right type fuses for various circuits
- How to determine proper size fuse or Fusetron to use for different applications
- How you can save material and cut costs on motor installations
- How to recognize a reliable make of fuses

and

- a lot of other useful information that will help you get more service out of your fuses.



SAVE FUSES

. . . Send for Your Copy of this Book

BUSSMANN MFG. CO. *Division McGraw Electric Company*
University at Jefferson, St. Louis

Please send me a free copy of FUSEOLOGY.

Name_____ Title_____
PLEASE PRINT

Company_____

Address_____

City & State_____

(*Continued from page 51*)

TABLE V

Analyses of Products in Abnormal Periods

	Pure benzol	Pure toluol
Distillation range	0.54	0.87
Acid wash test	0+	0+
Copper corrosion	0	0+
Freezing point	5.03	.....
Sp. gr. at 15.5 C	.8824	.8679

Xylol

Distillation:	
First drop	132.5 C
5 per cent	135.5 C
90 per cent	144.0 C
Dry point	150.0 C
Acid wash test	6+
Sp. gr. at 15.5 C	0.8624
Paraffins, per cent	6.2

DISCUSSION

L. R. MILBURN, Electrical Engineer, Great Lakes Steel Corporation, Ecorse, Michigan

C. R. LOHREY, Blast Furnace Division, Great Lakes Steel Corporation, Ecorse, Michigan

R. S. ERICSON, Assistant Works Auditor, Great Lakes Steel Corporation, Ecorse, Michigan

R. B. WINTER, Sales Engineer, H. O. Trerice Company, Detroit, Michigan

A. R. BORDEN, District Manager, Hagan Corporation, Detroit, Michigan

W. H. COLLISON, Superintendent, By-Product Coke Plant, Great Lakes Steel Corporation, Ecorse, Michigan

L. R. MILBURN: Do you extract or refine any paraffin, or does it all go into your solvent?

C. R. LOHREY: We do not refine any paraffin as such. In our work we refer to paraffins as a class of compounds, the physical characteristics of which range from the gas methane, to the common solid kitchen variety of paraffin. Hence the boiling points of the various paraffinic compounds range from very low to quite high temperature. In processing the light oil any paraffinic compound present whose boiling point is in the range of that of benzol will be contained in the benzol; and likewise any paraffinic compounds which boil at the same temperature as toluol or at the temperature of solvent naphtha will be contained in that particular fraction. To answer the last part of your question, the only paraffins that go into the solvent fraction are those compounds whose boiling points are in the boiling range of solvent naphtha.

R. S. ERICSON: Will Mr. Lohrey explain just how we get the light oil from the coke ovens? Some of us not so well acquainted with the process don't know how we get the light oil.

C. R. LOHREY: The light oil recovery process takes place in another part of the plant; that is the reason no mention was made of it in this paper. Very briefly, the raw coke oven gas from the ovens passes through a series of towers and other apparatus in which it is cooled, the tar, ammonia, etc., removed, and finally it passes through the light oil scrubbing towers, countercurrent to a flow of absorbent oil. As its name implies this oil absorbs light oil, then passes through a still where it is subjected to a live steam distillation which removes the light oil as vapor and allows the absorbent oil to pass on through coolers and again through the scrubbing towers. The vapors are condensed, the water removed by passing through a decanting tank, and the light oil flows to a storage tank in the benzol plant ready for processing.

R. B. WINTER: For what are these products used, and in what way are they different when used for peacetime and war-time?

C. R. LOHREY: The principle uses of these products are as motor fuel for internal combustion engines, for the manufacture of plastics, toluol for TNT of course, and in the paint industry. During war-time the amounts used for motor fuel and in the paint industry are probably quite small; however I have no data at hand and know of none at present that will give a very accurate answer to your question. Practically all of our benzol finds its way to the plastic industry.

A. R. BORDEN: What is the explanation for the low paraffin content of your light oil? Is that due to the coal mixtures, or is it special processing through the scrubbing oil that brings your paraffin content in naphtha down low?

C. R. LOHREY: I believe it is due largely to the type of oven and the manner of heating this oven. It may be affected somewhat by the choice of coals, but to what extent I am not able to say. We have used various coals and various coal mixtures and up to the present time this has not affected the quality of our products to any great extent. As was mentioned in the paper, during abnormal periods of operation, or in other words, periods of longer coking time the quality of the product was affected somewhat.

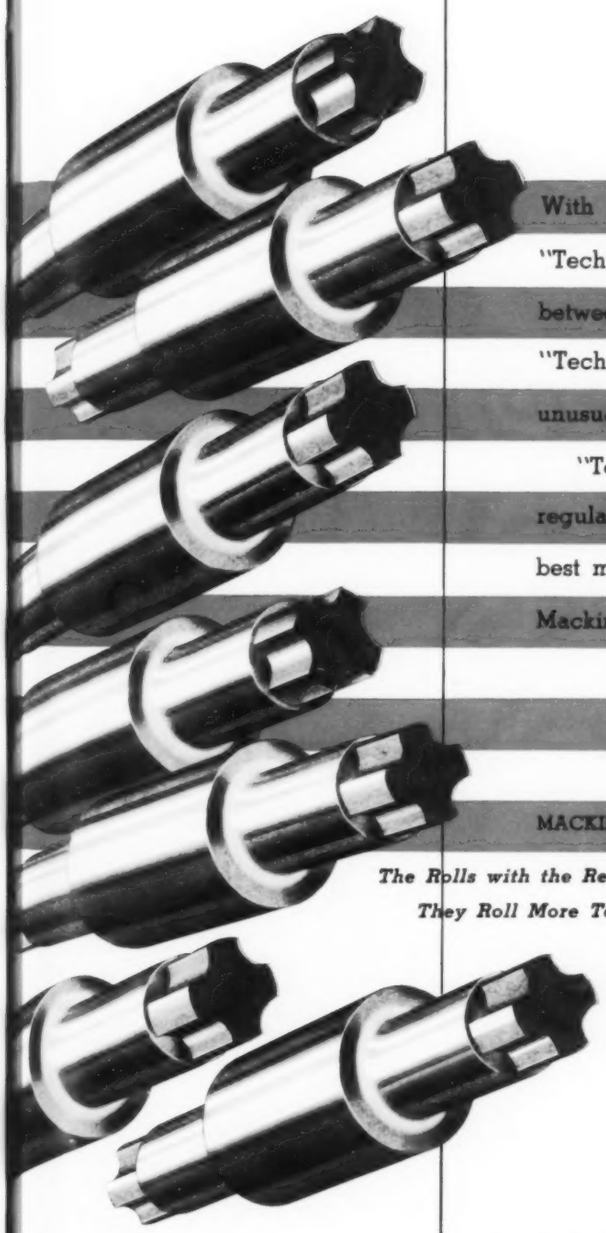
W. H. COLLISON: Mr. Lohrey touched on one point, that it is not necessary for us to have a column to separate intermediate products between benzol and toluol, despite the widespread distillation ranges. We have been told that we can successfully so operate because undoubtedly we have a superior grade of light oil. We are unable to see why our light oil should be appreciably different from light oils from other high temperature carbonization plants.

It is my belief that the chief factor determining paraffins is the temperature of the oven; other things being equal, that depends mostly upon the coking time.

For greater production

from your Rod, Merchant

and Bar Mills . . . .



With all stands of your Rod, Merchant and Bar Mills equipped with "Techni" Process Rolls you will get increased production and more rolled tons between roll dressings. These profit-making advantages are made possible with "Techni" Process Rolls because they have greater strength, excellent finish, unusual wearing qualities, resistance to slippage and fire cracking.

"Techni" Process was developed exclusively by Mackintosh-Hemphill. It regulates the quality and grain size of the rolls with as much exactness as the best modern steel practice regulates the quality of steel. Now more than ever, Mackintosh-Hemphill and "Techni" Process rolls will assist you to get the most for every roll-dollar you spend.

Since 1803—Pioneers, Engineers and Builders

MACKINTOSH-HEMPHILL COMPANY - - - - Pittsburgh and Midland, Pennsylvania

The Rolls with the Red Wabblers
They Roll More Tons Per Dressing

equip all stands with

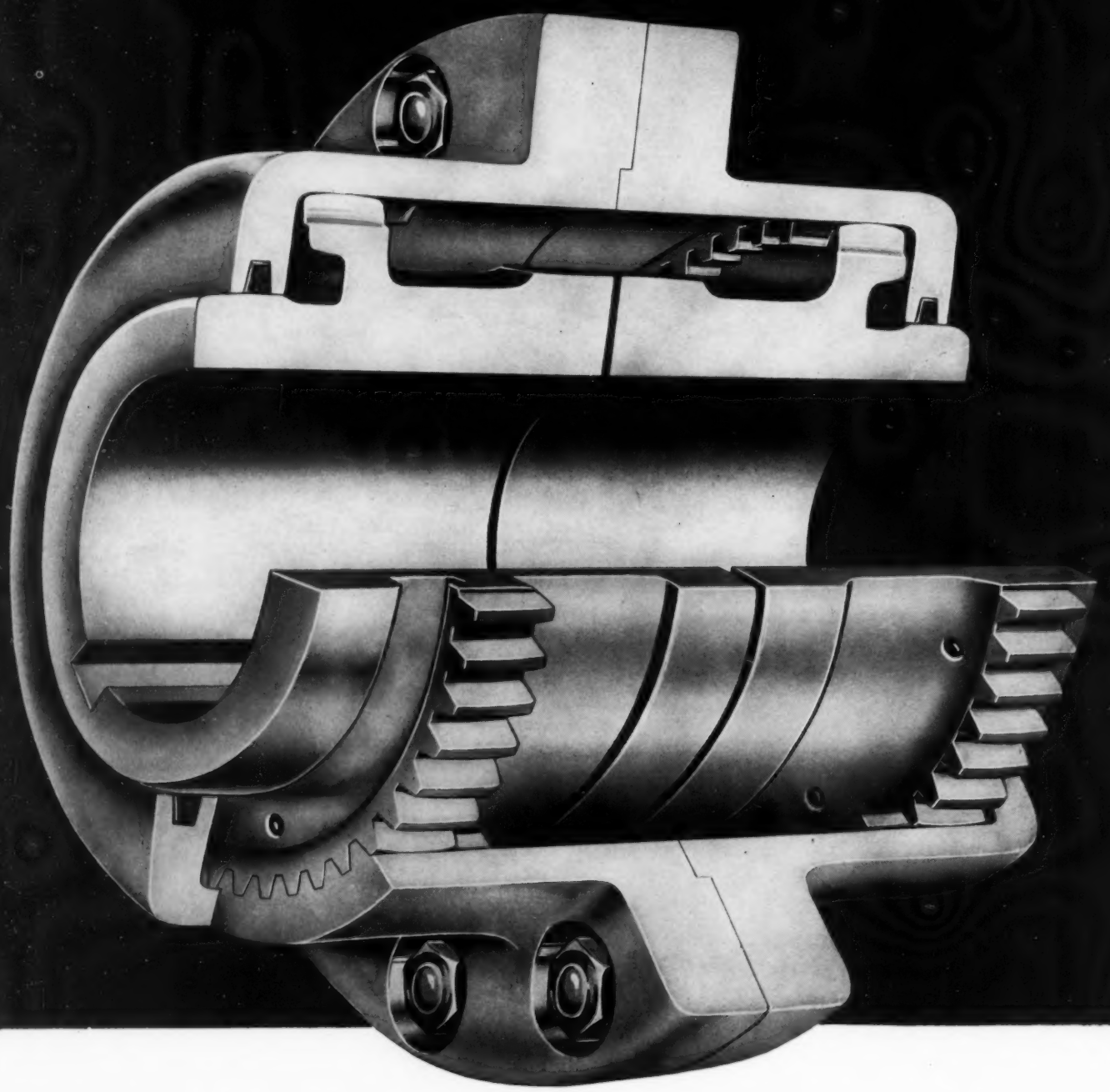
"Techni"

PROCESS IRON AND STEEL BASE ROLLS

OTHER MACKINTOSH-HEMPHILL PRODUCTS:

Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers . . . Pinions . . . Special Equipment . . . Iron-Steel Castings . . . The NEW Abramsen Straightener . . . Improved Johnston Patented Corrugated Cinder Pots and Supports . . . Heavy Duty Engine Lathes

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

This chart helps operators to do better Oxy-Acetylene Hand-Cutting

CORRECT PROCEDURES VS. COMMON FAULTS IN HAND-CUTTING
(1) Correct Procedure
Compare this cut in 1-in. plate with those below. The edge is square, the drag lines are vertical and not too pronounced.
(2) Preheat Flames Too Small
They are only about ⅛ in. long. Result: cutting speed was too slow, causing bad gouging effect at bottom.
(3) Preheat Flames Too Long
They are about ½ in. long. Result: surface has melted over, cut edge is irregular, and there is too much adhering slag.
(4) Oxygen Pressure Too Low
Result: top edge has melted over because of too slow cutting speed.
(5) Oxygen Pressure Too High
Nozzle size also too small. Result: entire control of the cut has been lost.
(6) Cutting Speed Too Slow
Result: irregularities of drag lines are emphasized.
(7) Cutting Speed Too High
Result: a pronounced rake to the drag lines and irregularities on the cut edge.
(8) Blowpipe Travel Unsteady
Result: the cut edge is wavy and irregular.
(9) Lost Cut Not Properly Restarted
Result: bad gouges where cut was restarted.
(10) Good Kerf
Compare this good kerf (viewed from the top of the plate) with those below.
(11) Too Much Preheat
Nozzle also is too close to plate. Result: bad melting of the top edges.
(12) Too Little Preheat
Flames also are too far from plate. Result: heat spread has opened up kerf at top. Kerf is tapered and too wide.
THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
New York and UCC Principal Cities
In Canada: Dominion Oxygen Company, Limited, Toronto

Refer to Form 5144 when writing for copies of this chart

Good results in oxy-acetylene hand-cutting depend not only upon the use of efficient equipment, but also upon flame adjustments, oxygen and acetylene pressures, cutting speeds, and the handling of the blowpipe. The chart illustrated is a convenient reference for oxy-acetylene operators. It shows them the results of some of the most common faults of cutting procedures and thus helps operators to keep their work at a high level. *This chart, which is printed on heavy stock 9 by 11½ inches, is available from any Linde office, without charge.* Also available upon request is the helpful booklet, "How to Increase Efficiency in Hand-Cutting Operations."

Operating Instructions

For information on correct gas pressures, nozzle sizes, and cutting speeds, refer to the Instructions furnished with your Oxweld, Prest-O-Weld, or Purox blowpipe. Duplicate copies of these Instructions are available from any Linde office.

THE LINDE AIR PRODUCTS COMPANY

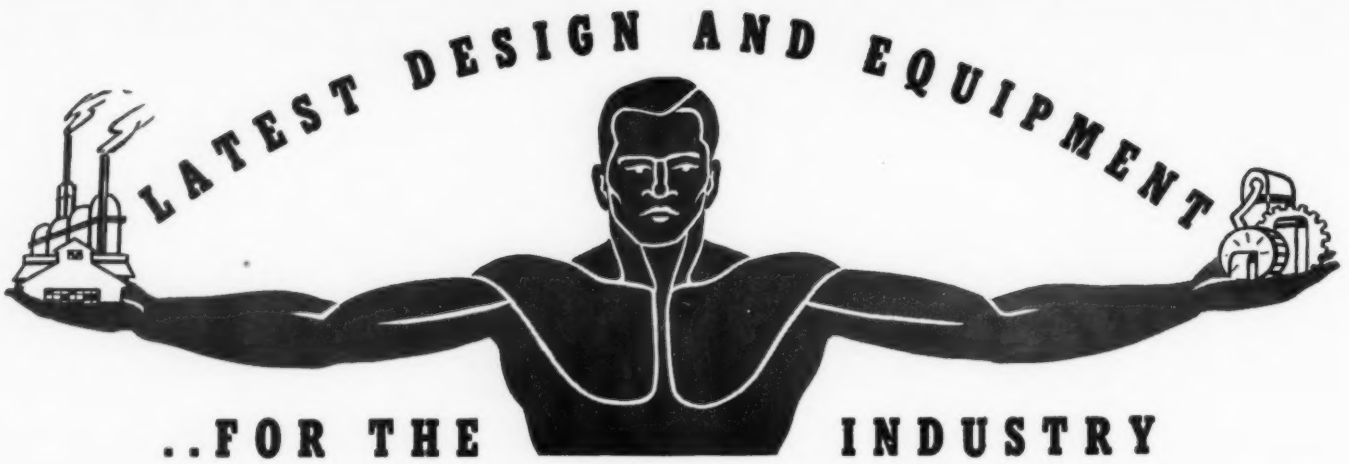
Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York, N. Y. UCC Offices in Other Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD APPARATUS . . . OXWELD SUPPLIES

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," "Purox," and "Prest-O-Weld" are trade-marks of Units of Union Carbide and Carbon Corporation.



PURCHASE EQUIPMENT FOR PLANT IN BRAZIL

▲ Orders for several million dollar's worth of electrical equipment for the largest and most modern steel producing plant in South America have been placed with the International General Electric Company, according to Major Carlos Berenhauser, Jr., electrical engineer of the Brazilian purchasing commission, now in this country.

The new steel mill will be erected at an estimated cost of $50,000,000, according to Major Berenhauser, who has rejoined the purchasing commission in Cleveland after several weeks of consultation in Schenectady.

The project is being built by the National Steel Co. of Brazil at Volta Redonda, a city eighty miles from Rio de Janeiro which eventually will accommodate some 20,000 persons. The plant and the city are being constructed along the most modern lines on what used to be farm land.

Production at the new plant is expected to get under way next year, turning out 300,000 tons of finished steel products the first year and eventually reaching an annual capacity of 750,000 tons. Before the war Brazil imported the bulk of its steel requirements, and Brazilian mills are now producing some 200,000 tons annually.

Two of the chief products of the new mill will be steel plates, for increasing Brazil's shipbuilding program, and railroad rails, for augmenting transportation facilities from the interior to coastal ports. Thus facilities for speeding such strategic ores as manganese, chromium, antimony, beryllium and lead to Brazilian defense plants or to American war industries will be greatly expanded.

I.G.E. will furnish main drive equipments for the rail and structural mills, for the hot strip mill, and for the continuous cold mill. The company has also been awarded a general contract for supplying the control equipments for various auxiliaries, as well as for cranes and for all general purpose alternating-current motor applications. I.G.E. will also furnish two 6250-kilowatt steam turbine generators for the power plant of the mills.

"The United States government is co-operating very closely to see the project through," Major Berenhauser explains. Because Brazil always has had to import steel plates and since the new mill will go far toward strengthening the preparedness of Brazil, priorities for material manufactured in this country are being provided. The U. S. Export-Import bank is helping finance the project, with a considerable amount of the financing coming from Brazil sources.

Lieut. Col. E. Macedo Soares, technical director of the project, was in this country for over a year laying the ground-work for the new steel

Among Brazilian government and business officials who visited General Electric's main plant recently in connection with the new Brazilian steel plant were the men pictured below with I. G. E. and G. E. officials. Left to right, front row, are Clark H. Minor, president of I. G. E., Air Brig. General Antonio Guedas Muniz, and R. H. Greenwood, president of General Electric, S. A. Rear row, Dr. Humberto Nobre Mendes, representative of the Sorocabana railway; W. V. B. Van Dyck, assistant to Mr. Minor; and Maj. Carlos Berenhauser of the National Steel Company of Brazil.

mill and is now directing construction on the scene. Foundations for the blast furnaces, expected to be in operation early next year, are already being completed. Improvements in railway and highway connections with Rio de Janeiro are also under way, and some 500 houses for workmen have been completed.

As an example of the size of the new mill, the rolling mill building alone will be 3000 feet long, all under one roof. Rolling mills, blast furnaces, open hearths, coke ovens and other plant sections will require some 50 miles of railroad track in the plant area. Most of the electrical power will be purchased from the Rio de Janeiro Tramway Light and Power Company at the outset, and a special 88,000-volt transmission line is being built to the site.

The site was chosen for its central location. Iron ore, reportedly the equal of the finest found anywhere in the world, will be brought to the mill by rail from mines in the state of Minas Geraes, 300 miles to the north. Coal and coke will be transported by ship to Rio de Janeiro and thence by rail to the steel plant from the mill's own and other mines in the state of Santa Catarina, 500 miles to the south. A coal-treating plant has been installed near the port of loading and port facilities are being improved for handling the large tonnages of coal.

Lieut.-Col. R. S. de Oliveira is head of the Brazilian purchasing commission in Cleveland of which Major Berenhauser is a member. The commission is employing the services of Arthur G. McKee and Company, consulting engineers in Cleveland, in mapping out details of the new mill and equipment required. Approximately $30,000,000 worth of equipment is being ordered in the United States.

Major Berenhauser until last year was a professor of electrical engineering in the Army Technical school in Rio de Janeiro, attended by Brazilian army engineers. He is a graduate of the Electrotechnical Institute of Itajubi, Brazil, and also of the Army Technical school, and was a member of the Brazilian Federal Power commission. He was given leave of absence by President Vargas of Brazil in order to join the purchasing commission in this country.

RECORD PLATE SHIPMENT

▲ Approximately enough steel plate for the hulls of two Liberty ships moved out of Indiana Harbor July 30 as a 24-hour contribution from a single Inland Steel mill to the war effort.

Three crews, totaling 664 men, took part in the successful effort to set a new shipping record for the 76-inch continuous strip mill — a record described as "amazing" by James H. Walsh, vice president in charge of Indiana Harbor operations for Inland.

The amazing part, setting it apart from the several other records established in various mills during July, resulted from the fact that this same mill set a new all-time shipping record less than a month ago and hadn't hoped to exceed it again for a long time.

This new mark exceeded by 25 per cent the total of plates shipped when the recent, all-time record was set. More than 75 gondola cars, loaded to capacity with the plates, were started toward the coasts during the 24-hour period.

Each of the three shifts set individual new records.

The 664 men making up the three crews for this single mill all played a part in setting the mark. While some of the plates being shipped were accumulated from the previous days, a major share was hot off the rollers and shears and went into the gondola cars while still smoking. A slowdown anywhere, from the men tending the slab

. . . "amazing record"

JAMES H. WALSH
Vice-president in charge of operations
Inland Steel Company

furnace down the long line of rollers through the shears onto the cradle and into the railroad cars, might have resulted in missing the mark.

The men on the rollers had their eyes throughout the 24 hours on another record, that for plate production, but didn't quite make it because of a brief, mechanical breakdown of one machine on the last shift.

Just to show that the other mills also are feeling the spur of war needs, Inland also announced a new record for the 14 in. merchant mill. This mill in one 24-hour period rolled a record-setting total of a steel particularly valuable to the war effort.

WPB REVISES PLANT EXPANSION

▲ A steel ingot capacity for the United States of 98,279,970 tons by mid-1943 has been recommended by the Iron and Steel Branch, War Production Board.

This is 9,710,000 tons more than the 88,569,970-ton present rated capacity of the industry and represents a 10 per cent reduction from the 10,762,000 tons originally approved following the authorization of the Supply Priorities and Allocations Board on September 30, 1941.

The recommendation was made in a review of the iron and steel expansion program prepared by W. A. Hauck, head of the steel planning unit of the Branch. The review was made by the Branch and by representatives of the Army-Navy Munitions Board following the order of WPB chairman Donald M. Nelson that all expansion programs be carefully reviewed to save as much critical material as possible.

Completion of the recommended program will present the picture of the nation's steel-making capacity in net tons as shown in Table I.

Not only ingots, but coke and pig iron expansion also have been curtailed in the revised program. Here are the current recommendations as contrasted with the original expansion authorizations, in tons, are given in Table II.

The increase in open hearth steel capacity will be obtained by three steps. New furnaces will provide 4,891,000 tons of the 7,692,000-ton increase; hot metal from blast furnaces, instead of cold scrap, will account for 2,163,000 tons, and restoring and enlarging old furnaces will bring in 638,000 tons.

Of the total increase in ingot capacity, 5,165,000 tons will be completed in 1942 and the additional 4,545,000 tons brought into production in the first six months of 1943. Many of the projects are well on their way to completion at present and some already are in operation.

No such increase in steel ingot facilities can be undertaken without a corresponding increase in pig iron capacity. In fact, the report calls for an even larger increase in raw materials facilities to make up for the reduced amount of purchased scrap expected next year and thereafter.

Thus the expansion program actually starts with the expansion of iron ore mining in New York, New Jersey, Texas, southern California and Utah.

A further step in this program is the construction of 21 new ore boats for the Great Lakes. These new carriers, in addition to present capacity, are expected to fill ore needs through 1944 and thereafter.

The increase in pig iron capacity is to be brought about by these steps:

	Tons
From 20 new blast furnaces	8,118,000
From 6 abandoned furnaces restored	1,235,000
From enlargment of 9 existing furnaces	853,000
From use of sintered ore	599,000
From use of thinner furnace linings	140,000
	10,945,000

STEAM PLANT
Before
After
INTEGRAL MOUNTED TYPE
REMOTE PANEL MOUNTING
HOW HAYS
COMBUSTION METER
Improves
Boiler Operation
THE two segments of charts shown above, taken from a Hays Combustion Meter installed in a north west paper mill tell a graphic and convincing story. Upper chart shows the low and erratic CO_2 the first day of operation, typical of the wasteful method of firing before installation of meter. Lower chart shows results exactly one week later, after the meter had taught the operators how to fire the boiler properly — fuel saved, smoke eliminated, more heat secured, steam pressure more constant.
Send
FOR THIS
HANDSOME
NEW BOOK
It contains complete information on CO_2 —its significance and measurement. It's FREE.
HAYS
The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

1942 will see the completion of 6,349,000 tons of this total, with the remaining 4,596,000 to be completed in 1943. Completion of the pig iron program will make 70,351,410 tons available, with 9,500,000 tons necessary for merchant iron and ferro alloys. This leaves 60,851,410 tons available for steel making.

Full use of the entire 98 million tons of steel capacity will require 109,463,223 tons of metallics, made up as follows:

	Tons
Pig iron	60,851,410
Plant scrap	26,828,607
Metal in ore	5,834,400
Purchased scrap	16,000,000

These sources provide surplus metallics of only 51,194 tons provided purchased scrap is a constant figure. The report recommends additional pig iron capacity to insure against declines in the purchasable scrap supply.

In addition to the steel expansion program, the report also lists a 70 per cent increase in steel foundry facilities to make vital war castings.

The program in detail:

	Tons
Sponsored by WPB	223,560
Privately financed	501,024
Sponsored by War Department	628,200
Sponsored by Navy Department	41,700
Total expansion	1,394,484
Annual capacity, July 1, 1941	1,896,000
Total proposed capacity	3,290,484

Ingot capacity of 98 million tons, the report points out, will provide 68,796,000 tons a year of finished steel products. These may be distributed as the needs of the war determine, as finishing facilities are approximately 30 per cent higher than metallic capacity. Present finished products capacity is approximately 62,098,979 tons.

TABLE I

	December 31, 1941	June 30, 1943
Pig iron	59,406,410	70,351,410
Ingots:		
Electric	3,741,310	5,759,310
Bessemer	6,721,400	6,721,400
Open hearth	78,107,260	85,799,260
Total ingots	88,569,970	98,279,970

TABLE II

	Original expansion	Present program	Per cent of reduction
Coke	9,359,000	7,083,000	24
Pig iron	13,810,550	10,945,000	21
Ingots:			
Open hearth	8,744,000	7,692,000	12
Electric	2,018,000	2,018,000	None

CONTRACT FOR COKE PLANT IN CHINA

▲ The Otto Construction Corporation of 500 Fifth Avenue, New York, has been awarded a contract for a complete by-product coke oven plant, to be built in China. The project calls for one battery of the latest design of Otto entire underjet hairpin flue ovens, which will be underfired by either coke oven or blast furnace gases. The by-product installation will include equipment for the recovery of benzol and toluol and a tar distillation plant.

AMERICAN STEEL MISSION TO BRITAIN

▲ An American steel mission is being sent to Great Britain to attack with the British the problem of steel production for war use on a united basis.

The mission, including steel-producing authorities, Army, Navy and other government officials, will study British methods and requirements and investigate means of increasing the quantity of steel needed for the war efforts of United Nations and obtaining maximum efficiency in the use and allocation of the combined productive capacity of the two countries.

It is hoped, an announcement of the Combined Production and Resources Board said, that a British steel mission also will visit the United States to make a similar study when the American group returns.

Members of the commission are Chairman Charles R. Hook of Middletown, Ohio, president of the American Rolling Mill Company; Paul F. Schucker of Washington, chief of the Lease-Lend and Import Section, Iron and Steel Branch, WPB; Lieut. Col. Paul P. Llewellyn of Washington; Captain G. A. Duncan, for the Navy; Walter S. Tower of New York City, president of the American Iron and Steel Institute, and Earl C. Smith of Cleveland, chief metallurgist for the Republic Steel Corporation.

Announcement of the arrangements pointed out that appointment of the mission and the plans for its visit were rounded out a week after the Combined Production and Resources Board had held its first formal meeting. Sir Robert Sinclair, deputy for Oliver Lyttelton, Britain's Minister of Production and that nation's representative on the board, arrived in this country on July 25. The American member of the board is Donald M. Nelson, chairman of the War Production Board, and James S. Knowlson, vice chairman of WPB, is his deputy.

Appointment of the mission, the announcement said, is based on the fact that the capacity of the United States and Britain to make weapons of war out of steel is now greater than their combined capacity to produce this vital basis of war supplies, thus making it necessary that every pound of productive capacity of both coun-

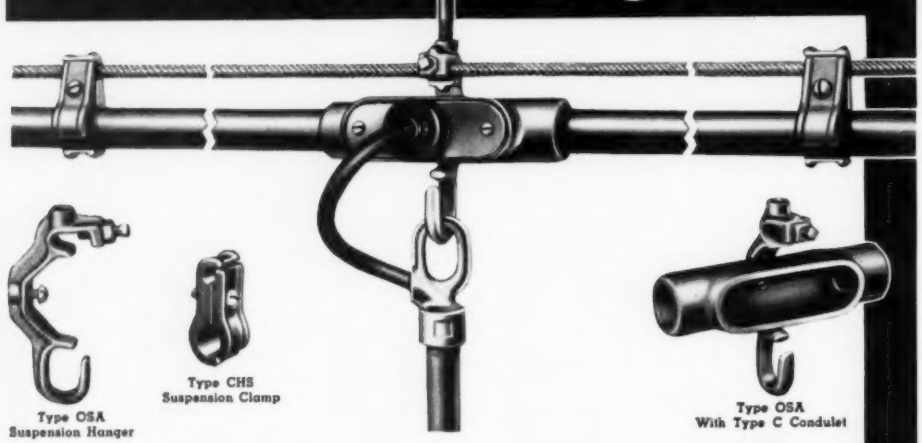
tries be used as efficiently as possible so that the greatest possible number of war machines can be thrown against the enemy.

The American mission, it was indicated, will study the following problems:

1. Ways to increase total production of steel in the United States and Great Britain.
2. The British system for control of steel production, allocation and distribution.
3. How the steel programs of the two nations can be brought into better balance so that plates, shapes, structural steel and so on will all be produced in the proper ratio.
4. Whether increased production and savings in shipping space can be effected by sending more ingot steel and less finished weapons to Britain or vice versa.
5. What steel products can best be made in the United States and what can best be made in Britain.
6. Which theatres of war should be supplied from Britain and which from the United States to economize on shipping space.
7. Methods used by Britain to collect steel scrap and the use that is made of the scrap.
8. British progress in reducing steel consumption by substitution, simplifying specifications and eliminating wasteful machining operations and means for pooling such information by the two countries.
9. What percentage of British steel production is used, respectively, in war and civilian production.
10. Means of obtaining savings in the use of scarce alloy steels.

. . . goes to Britain
CHARLES R. HOOK
President
American Rolling Mill Company

CROUSE-HINDS
Type OSA Suspension Fixture Hangers



In industrial buildings where it is necessary to suspend lighting fixtures at some distance below the ceiling or roof structure, span wires may be stretched across the areas as the supporting means. Type CHS clamps and type OSA suspension hangers are used for hanging the conduit, the fixture outlet Condulets, and the fixtures from the span wires.

When installed, type OSA suspension hanger is attached to the fixture outlet Condulet (Form 7 Obround) and hooked over the span wire, thereby supporting both the Condulet and the fixture. The lower hook which supports the fixture is so shaped that the fixture and stem assembly cannot be accidentally disconnected. The span wire is clamped in the upper hook by a set screw with lock-nut. Additional support may be obtained by use of a ⅜-inch rod screwed in the upper end of the OSA hanger and attached to the ceiling or roof structure.

Type CHS clamp grips both the span wire and the conduit. It is not necessary to remove the screw to place the clamp in position on the span wire and conduit.

The cover opening of the Condulet can be equipped with an Obround attachment plug receptacle which will permit the fixture to be wired with an attachment plug cap, thereby providing easy removal of the fixture for cleaning. Obround one-wire hole covers can be used instead, if removal of the fixtures is not desired.

A Nationwide Distribution Through Electrical Wholesalers

Condulet Catalog No. 2500 will be sent on request.

CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.

Sales Offices: Birmingham — Boston — Chicago — Cincinnati — Cleveland — Dallas — Detroit — Houston — Kansas City — Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington
Resident Salesmen: Albany — Atlanta — Baltimore — Buffalo — Charlotte — Denver — Louisville — New Orleans
CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

C-I ESTABLISHES PRODUCTION RECORDS

▲ Furnaces of Carnegie-Illinois Steel Corporation, U. S. Steel subsidiary, in July broke nine important monthly production records, including outstanding performances in both iron and steel making.

July output was featured by a new all-time high for a single month's production of iron, when the com-

pany's blast furnaces turned out 1,458,728 tons. The best previous record was established in May.

Among the best performances in the Pittsburgh district of Carnegie-Illinois was that of the open hearth department at Farrell, Pennsylvania, Works, which produced 90,684 tons of steel ingots, surpassing its March, 1942, record.

All Carrie blast furnaces at Rankin, Pennsylvania, shared in setting a new high of 184,104 tons of iron in July, topping May, 1942, their best previous month.

A single blast furnace at the Edgar Thomson Works exceeded its January, 1942, peak by turning out 35,691 tons of iron.

TRUCK DESIGN GIVES FLEXIBLE OPERATION

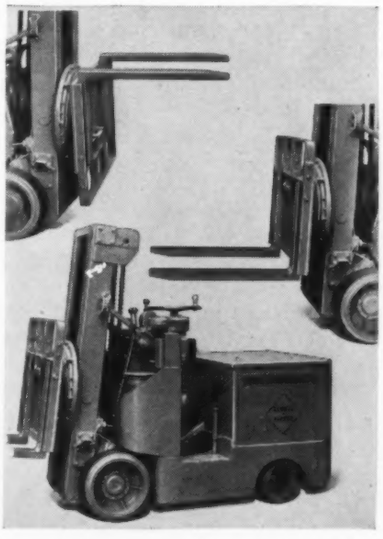
▲ The Elwell-Parker Electric Company is supplying its center control truck, Type F-23T, with forks on a rotating base capable of making a complete revolution. Should the work call for only a partial revolution, however, as for body dumping into gondola cars, the base can be provided with stops to limit the swing to any angle up to 180 degrees.

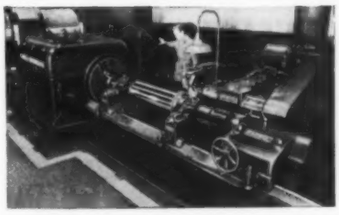
Rotating forks increase the usefulness of the truck and adapt it to a wider variety of jobs. At top position, the forks carry either suspended or supported loads — the latter for extra high tiering. When locked into place at the bottom, they handle pallets or low skids with no adjustment whatever. For handling roll paper, the forks are interchangeable with rotating apron to pick up or deliver roll on end or side.

The truck is electric-powered, with front wheel drive and rear wheel steer. It handles up to 4000 pounds and travels up to 5 miles per hour with full load. Tilting uprights are 83 in. high when telescoped and can be extended to 140 in. high.

Travel brake is foot-operated. When operator steps from his position on the truck, power is shut off and the brake applied automatically. Speed on ramps is controlled by dynamic brake. This truck is listed under the Underwriters' Laboratories' re-examination service.

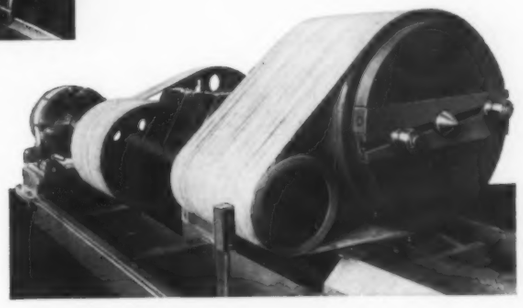
This center control truck has forks on a rotating base capable of making a complete or partial revolution.





Left — One of six Farrel 36" x 16.0" Heavy Duty Roll Grinders installed in strip mill.

Below — Multiple V-Belt Headstock Drive for 60" Roll Grinder.



SMOOTHER FINER ROLL FINISH OBTAINED

by the VIBRATIONLESS MULTIPLE V-BELT HEADSTOCK DRIVE *of*

FARREL ROLL GRINDERS

The multiple V-belt headstock drive of the Farrel Heavy Duty Roll Grinder produces results in finer roll finish and increased output that formerly had been thought unattainable on any roll grinder. Its smoothness of operation and freedom from vibrations contribute materially to the rapid grinding of perfect surfaces free from all marks.

The Farrel headstock is a self-contained, compact, rugged unit which will give many years of trouble-free service with a minimum of attention and upkeep. Note these features: (1) Headstock mounted on same level and in line with grinder beds — no special pit required. (2) Number of belts is ample to rotate any roll within the capacity of the grinder. (3) Belt sheaves and large faceplate pulley mounted on precision type, anti-friction bearings. (4) Each reduction separately adjustable to give proper belt tension without the use of idler pulleys.

Farrel Heavy Duty Roll Grinders have many other important features which contribute to superior performance, better finish and increased output. For complete details write for a copy of Bulletin No. 111.

FARREL DRIVES *for* VICTORY

FARREL

FARREL-BIRMINGHAM COMPANY, Inc.
ANSONIA, CONN.
New York • Buffalo • Pittsburgh • Akron • Chicago • Los Angeles

ANNOUNCES NEW ARC FURNACE CONTROL

▲ A revolutionary, new electric arc furnace control, just announced by the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, will greatly increase the wartime efficiency of electric furnace steel production in steel plants and foundries, preliminary applications indicate.

For the new furnace electrode control the company has applied its "Regulex" exciter, already in use by many companies for accurate, sensitive control on temper pass and reversing mills. Extreme accuracy is claimed for the new "Regulex" control as a result of quick reversing and smooth acceleration, while greater production is expected with the reduction of operating troubles and maintenance.

The "Regulex" exciter controls arc energy to a constant quantity without the use of contact-making devices. Control field windings that measure arc current and volts are part of the fast-acting control element used in this method of electric arc furnace control. With its voltage controlled by the "Regulex" exciter, the small generator supplying power to the electrode motor causes the motor to raise or lower the electrode as required by uninterrupted Ward-Leonard control.

The variable voltage control eliminates high voltage inrushes which, with the elimination of contact maintenance, reduces production delays to a minimum. According to the manufacturer, the advantages the new product offers can be expected to contribute to the rapid increase in electric furnace steel output, already doubled under war-time demands in the last two years.

★ RYAN ★
AUTOMATIC DOOR LIFT
COMPACT · EASILY INSTALLED
· LOW COST ·
WRITE FOR BULLETIN No. 101-A
For
FURNACE AND OVEN DOORS
ALSO DIPPING BASKETS
AND MANY TYPES OF
INDUSTRIAL LOADS...
EACH HORSE POWER LIFTS UP TO 6,000 POUNDS!
Takes the IF out of LIFT!
ENGINEERED FJR EQUIPMENT
FRED J. RYAN COMPANY
LOCATED IN A PHILA. SUBURB . . . WYNCOTE, PA.

NAVY "E" AWARDED FOR PRODUCTION

▲ For outstanding achievement in the production of turbines, gears, pumps and other equipment vital to the United States Navy, the Navy "E" burgee, symbol of "Work Well Done," was presented to the De Laval Steam Turbine Company, Trenton, New Jersey, June 29, 1942, at which time also the employees received the "E" lapel insignia. The presentation speech made by Rear Admiral William C. Watts, U.S.N., Ret., was responded by H. L. Watson, executive vice-president of the De Laval Company. Other speakers were the Hon. John A. Hartmann, Mayor of Trenton, and Judge Harold C. Wells, of the Court of Errors and Appeals of New Jersey. The presentation ceremonies were held in the War Memorial Building at Trenton and were attended by about 1800 De Laval employees and invited guests. Among the latter were numerous officers of the Navy and Army and officials of shipyards and concerns manufacturing marine equipment. The presentation ceremonies were followed by a reception and buffet supper at the Trenton Country Club.

To date over eleven million horsepower of De Laval marine turbines and speed reducing gears have been delivered, or are under construction, for the propulsion of destroyers, cruisers and merchant vessels, as well as large numbers of centrifugal pumps for marine service, De Laval-IMO rotary displacement pumps for fuel and lubricating oils, centrifugal compressors for submarines, and worm reduction gears for use with steam turbine-driven auxiliaries.

The De Laval-IMO OIL PUMP

runs at gasoline engine, as well as at motor or turbine, speeds, making a clean, compact and neat unit in any combination.

The engine-driven unit shown serves as standby for a similar motor-driven IMO, insuring continuous supply of oil to burners in case of interruption to electric power.

Ask for Publication I-92.

IMO PUMP DIVISION
of the De Laval Steam Turbine Company, Trenton, N. J.

Steel Mill PLATE STAMPING

Slab section and sheared plate identification is rapidly stamped with Matthews Plate Stamping Holders. Of tool steel construction, they are light in weight and very durable. Easy to handle! The "Shepherd-Hook" holding device eliminates "wrong - side - up" stamps. Stamps cannot fall out or fly out on rebound from hammer blows. Safe, rapid and definite stamping.

Steel stamps are held in place by a properly tempered "Shepherd-Hook." They are quickly and easily changed. Holders are made for any required quantity of stamps. Write for literature and prices. State character size and number of characters to be stamped.

Same holder made for marking pipe, rounds, etc.

JAS. H. MATTHEWS & CO.
3942 FORBES ST. :. PITTSBURGH, PA.
New York—Chicago—Phila—Boston—Detroit—Newark—Syracuse
DISTRICT SALES OFFICES - CLEVELAND - HARTFORD - BIRMINGHAM

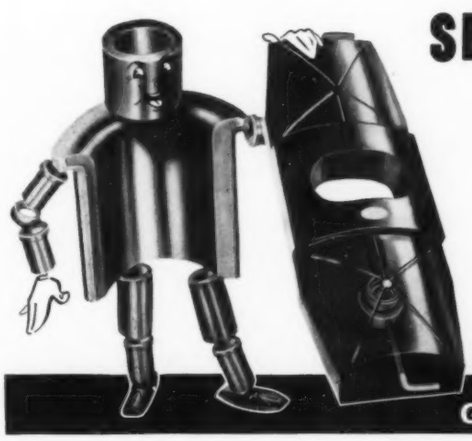
SCRAP RECLAIMED BY DUMP MINING

▲ In a move to help relieve the acute scrap shortage by industry, blast furnace and open hearth slag dumps in the Pittsburgh district of Carnegie-Illinois Steel Corporation, U. S. Steel subsidiary, are being searched for cast-off metals that are being salvaged for war production at a rate of 50,000 tons annually.

Reclaiming operations are in progress at the Gascola, East Side, Risher and Brown slag dumps in the immediate Monongahela valley district, and also at Vandergrift, Youngstown, Farrell and Mingo Junction.

In every instance, the scrap recovery work is being carried on by outside contractors who recover, prepare and ship the scrap to Carnegie-Illinois open hearth furnaces. Reclaimed scrap is required to meet specification standards and is paid for on the basis of a flat rate per ton.

During June, 4825 tons of scrap satisfactory for war use were recovered from these slag dumps.



SELF-ALYN SLIPPER BEARINGS

The GATKE Invention that Revolutionized Universal Coupling Performance . . .

- 10 times longer service.
- Eliminate Socket Scoring and Wear.
- *Avoid costly machine shop work.*
- End destructive vibration.
- Stop pounding noises.
- Prevent Grease slinging.
- Made to fit without machining for all sizes and types of UNIVERSAL COUPLINGS.
- Information on request.

Gatke MOULDED FABRIC Bearings

GATKE CORPORATION - 228 N. La Salle - CHICAGO

ITEMS OF INTEREST

Don N. Watkins has been appointed chief of the steel plant facilities section of the War Production Board. This section consists of the planning, maintenance, and construction units of the Iron and Steel plants.

Mr. Watkins has been chief of both the construction and refractories units of the iron and steel branch.

R. C. Allen, deputy chief of the iron and steel branch, who was formery chief of the plant facilities section, has relinquished that position to devote his entire time as assistant to Mr. Taylor.

DON N. WATKINS

S. H. Mortensen, engineer-in-charge of a-c design for 10 years, has been appointed chief electrical engineer of the Allis-Chalmers Manufacturing Company plants at West Allis, Cincinnati, Boston and Pittsburgh.

Starting at the Allis-Chalmers Norwood works in 1905, Mr. Mortensen transferred to Milwaukee as an electrical draftsman three years later. There he successively became design engineer for d-c machines, design engineer of rotating synchronous machines, and in 1932 engineer-in-charge of alternating current design.

Victor H. Lawrence has been appointed general superintendent of the Otis Works of Jones and Laughlin Steel Corporation at Cleveland, Ohio.

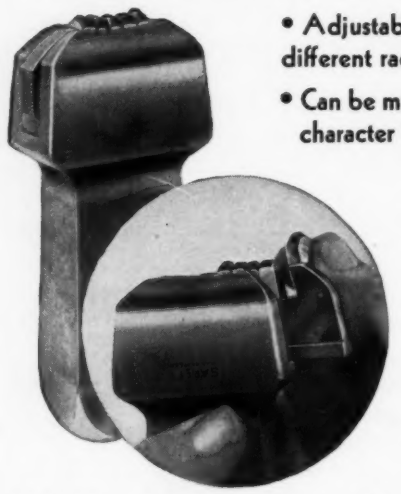
After studying civil engineering at Lawrence University, Mr. Lawrence finished his schooling in metallurgy at the Carnegie Institute of Technology and the Graduate School of the University of Pennsylvania. Since 1917 he has been engaged in the construction, operation, engineering and metallurgical phases of steel

VICTOR H. LAWRENCE

manufacture with several companies. In August of 1941 Mr. Lawrence joined the organization of the Otis Steel Company as assistant to the president.

WANTED — Man wanted for position of chief tool designer with large aircraft firm in the South. Must have had at least 12 years' experience in aircraft tooling of which 6 years should be in tool design. Write application to Box 4, Iron and Steel Engineer, 1010 Empire Building, Pittsburgh, Pennsylvania, stating experience, age, salary and personal photograph.

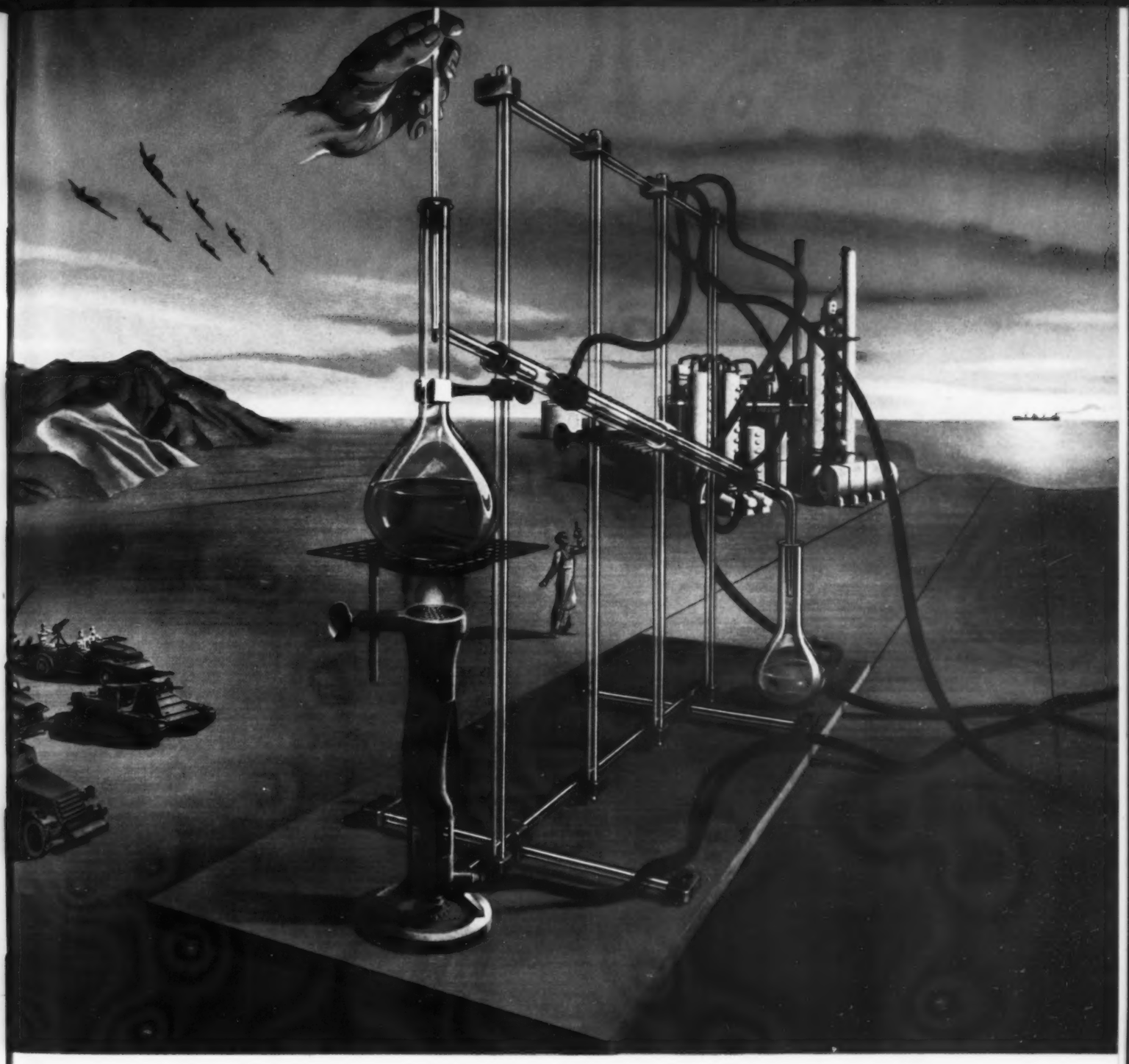
FOR STAMPING "ROUNDS"
SAFETY
WEDGE GRIP RADIUS HOLDER



- Adjustable for stamping different radii.
- Can be made for any size character 1/8" and up.
- SAFETY STEEL— construction insures against spalling and mushrooming.
- Ideal for stamping shells, round bars, axles, etc.
- Can furnish our BOX STYLE RADIUS HOLDER for hot marking of shell forgings and axles.

Write for complete information.

M. E. CUNNINGHAM CO.
105 E. CARSON ST. PITTSBURGH, PA.



Chemistry is putting miracles on a mass production basis

If ever a "secret weapon" does emerge from all this welter of war, it will most likely be a chemical development. And the American chemical industry has as good a chance of discovering it as any other, for America now has the greatest synthetic organic chemical industry in the world.

This industry looks to coal tar chemicals for almost half the raw materials it uses. Koppers is at the very roots of these chemicals.

Koppers toluene goes into TNT, the principal military bursting charge. Koppers benzene is used in the manufacture of explosive stabilizers, and "boosters" for primers. Koppers naphthalene helps minimize the flash in powders.

Most explosives are made using combinations of nitric and sulfuric acids. Koppers coke ovens produce ammonia and this helps meet the extraordinary demand for fixed nitrogen and increases the amount of nitric acid available for the war effort.

The Koppers Phenolate Process helps the petroleum and the coking industries recover more sulfur which is converted into sulfuric acid.

Koppers tar acids and naphthalene find use in synthetic plastics for airplanes, tanks, etc.; naphthalene is used in chemicals for synthetic and natural rubber. Pyridine is an ingredient in the new process for waterproofing military fabrics for jeep tops, tents, etc. Flotation sulfur is one of the principal spray materials for fruit crops.

Koppers serves the chemical industry in peace as well as war. Of the hundreds of coal tar intermediates, dyes and medicinals, about 87% are produced in greater or less degree from benzene, toluene, naphthalene, and phenol. Koppers is one of the principal sources of these and other basic materials.
—Koppers Company, Pittsburgh, Pa.

Buy United States
War Bonds and Stamps

KOPPERS

THE INDUSTRY THAT SERVES ALL INDUSTRY

Workers in our Bartlett Hayward Division are now privileged to wear the Navy "E" emblem

THE first bomb dropped on Pearl Harbor literally exploded in every steel mill. Men worked like fiends. Tonnage records were broken all over the country.

But, now we've settled down to the grim business of maintaining *steady, high* production. It will take more sustained effort and better equipment to continue breaking records.

During the last few years, many open hearths have been equipped with Hagan Automatic Furnace Control. One after another they have stepped up tonnage. In every case operating conditions were improved . . . in some cases extraordinary increases in tonnage were reported.

Hagan Automatic Furnace Control provides one of the quickest and surest ways to increase capacity. Better heating cuts down tap-to-tap time—sometimes an hour or two per heat. Existing furnaces can be easily equipped with Hagan Control. No additional furnace space is required.

Hagan Control will also step up capacity of blast furnace stoves, soaking pits and other bar and billet heating furnaces. You not only get increased tonnage, but more uniformly heated steel which rolls better with fewer rejects.

Get the complete story of Hagan Automatic Combustion Control and what it can do for you. Just write.

HAGAN OPEN HEARTH FURNACE CONTROL PROVIDES:

1. **Fuel input control,** for regulation of heat input of the fuels burned.
2. **Fuel-air ratio control,** to admit air in exact ratio each fuel requires for best efficiency.
3. **Furnace pressure control,** by regulation of stack damper.
4. **Reversal control,** for furnace reversal on basis of time cycle, temperature difference or both.

HAGAN CORPORATION · HAGAN BUILDING · PITTSBURGH, PA.

HAGAN *Automatic* COMBUSTION CONTROL
The pioneer . . . and still the leader

THE NEED FOR SAFETY OF EMPLOYEES

EVERY lost man-hour of production tends to postpone and *actually jeopardize* final victory. Faulty equipment does the work of saboteurs! . . . by exposing workers to injury and destroying the will to work long hours at top speed. Morgan Rolling Mills promote safety and morale by operating smoothly, efficiently, in spite of all-out pressure . . . because Morgan's 50 years' experience has made it possible to *anticipate* trouble sources . . . and eliminate them in the blueprint stage!

MORGAN
WORCESTER
ENGINEERS AND
MANUFACTURERS

MORGAN CONSTRUCTION COMPANY • WORCESTER, MASSACHUSETTS

R-102

Cut down on bearing failures and prevent delays in producing war orders

You can automatically lubricate every bearing on a machine with a

LINCOLN CENTRO-MATIC LUBRICATING SYSTEM

Speed-up war production with the aid of a Lincoln Centro-Matic Lubricating System . . . Easily installed on new or old machines, and makes it possible to lubricate all bearings from a single source . . . Permits machines to run 7 days and 7 nights a week without taking time out for lubrication service.

A Centro-Matic System consists of a number of Centro-Matic Injectors—one for each bearing—and a hand operated or a power operated Centro-Matic Lubricant Pump. A power operated system can be semi-automatic or it can be full automatic. The injectors can be grouped in manifold or located separately at each bearing. In either arrangement only a single lubricant supply line is required.

Send for COPY of BULLETIN 888
—or send us specifications of the machinery to be lubricated, and our engineers will gladly make recommendations. No obligation.

142-19

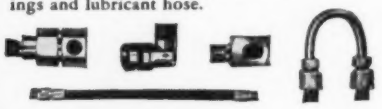
LINCOLN ENGINEERING COMPANY
Pioneer Builders of Engineered Lubricating Equipment
ST. LOUIS, MISSOURI

SIMPLE TO INSTALL

Lincoln Model 1787 Air motor operated, 400-lb. drum pump. Pumps lubricant direct from original refinery container and is full automatic with time clock control.

Lincoln Centro-Matic injectors are furnished in two types—block type for manifold grouping. Cylindrical type for widely spaced bearings.

Lincoln grease line accessories—high-pressure fittings and adapters, connectors, connector tube assemblies, compression couplers, bushings and lubricant hose.



Lincoln Model 1840 fully-automatic electric Lubrigun, 30-lb. capacity.

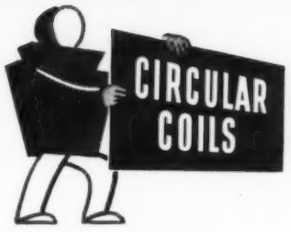
Lincoln Model 1805, Manually operated Centro-Matic Pump, 2-lb. capacity.

Transformer Fundamentals

...that insure unfailing power supply to *war industries.*

The fundamental improvements outlined below are the result of Pennsylvania's continuous research and development to assure greater transformer reliability, lower operating costs and longer life! They are but a few of the many improvements to be found in Pennsylvania Transformers.

23,500 KVA
55°, 115 KV
3-phase



. . . Possess Maximum Inherent Strength

In a circular coil the tension of each turn of wire is uniform throughout its length. No coil of any other shape possesses this quality.

The turns in a circular coil are wound tightly without excessive tension on the wire—thus eliminating the possibility of stretching the winding and injuring the insulation. This added safety is inherent in Pennsylvania's circular coil construction.

. . . to withstand short circuits

All coils of the helical and pancake type are precompressed to such an extent that no further compression can take place under the most severe short circuit. This definitely precludes any possibility of the coil stack moving or distorting under short circuit.

The ability of the coil to maintain its shape under the prescribed pressure is your guarantee that the transformer will withstand short circuits.

. . . with Silver-to-Silver Contacts

Pennsylvania's straight line tap changer with its silver-to-silver contacts is capable of carrying heavy overloads without overheating and is able to withstand "dead" short circuits without detrimental effects.

Tests have been made to fully prove these characteristics, the tap changer being subjected to 100,000 full operations—more than would occur during the normal life of the transformer.

Pennsylvania TRANSFORMERS

Pennsylvania TRANSFORMER COMPANY

808 RIDGE AVENUE, • N. S., PITTSBURGH, PA.

PERFORMANCE

that spells . . .

YOUR specific problem—*not all industry's*—gets solved when you rely on Birdsboro *Individualized* Roll Service. Find out *now* how to get extra roll life and more tonnage with Birdsboro Rolls.

Builders of

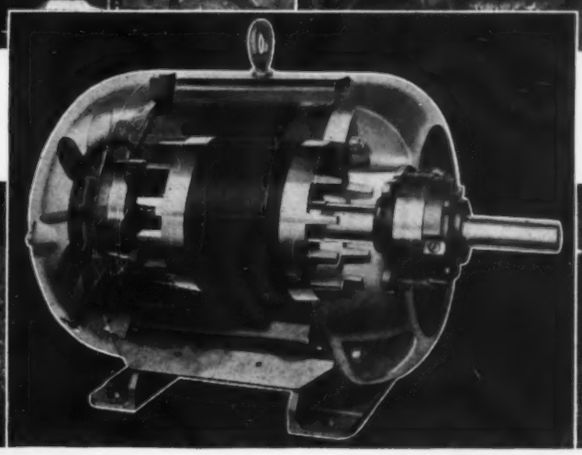
Rolls · Hydraulic Presses
Steel Mill Equipment
Crushing Machinery
Special Machinery

BIRDSBORO STEEL FOUNDRY AND MACHINE CO. • Plants at Birdsboro and Reading, Pa.

BIRDSBORO

ROLLS

Typical installations showing Wagner CP motors on the job, giving dependable service in steel plants. Thousands of these motors, now driving equipment in the steel industry, have proved their reliability.



The phantom illustration, at left, shows the sturdy construction of Wagner CP motors. No acid fumes, steam, or conductive or abrasive dust, can reach the vital parts to cause damage to the motor.

Here's WHY WAGNER *CP* MOTORS CAN DO AN *"ALL-OUT"* JOB FOR YOU....

In steel plants, where dust, dirt, abrasives, steel chips, filings, acid fumes, and other harmful elements are present, Wagner CP motors can perform an "all-out" service.

Here are a few of the many reasons why Wagner CP motors stay on the job and give longer service.

1..Two-frame construction—an outer frame guides a strong, cooling draft over the motor, while an inner frame completely seals the vital parts of the motor against the entrance of destructive or injurious materials. **2**.. Rugged, welded all-steel stator with specially impregnated windings. **3**.. Dynamically balanced rotor, equipped with sturdy shaft having all keyways end-milled. **4**.. Full-cartridge-bearing construction which completely seals and protects the ball bearings. **5**.. Easily accessible grease plugs, permitting lubrication without removing fan shield or stopping motor. **6**.. End-plates heavily and ruggedly constructed, with air deflector on shaft end. **7**.. Single-end ventilation with non-clogging, one-piece fan of split-hub construction. **8**.. Fan shield which is formed from sheet steel, can be easily removed for access to fan. **9**.. Nine leads connectable for either 220 or 440 volts completely sealed in outlet, making it impossible for abrasive materials to enter motor.

Field Engineering Service!

... PITTSBURGH, NEW YORK, CHICAGO and all of the rest of Wagner's 25 Branches are manned by trained field engineers competent to solve your motor application problems.

BUY U.S. WAR BONDS

Send FOR YOUR COPY OF THIS BULLETIN

WAGNER ELECTRIC CORP.
6400 Plymouth Avenue,
St. Louis, Mo., U. S. A.

Gentlemen:

Please send me copy of Bulletin MU-182.

Name_____ Postion_____

Firm_____

Address_____

City_____ State_____

I&SE M42-26

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

MOTORS · TRANSFORMERS · FANS · BRAKES

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Motors Down For Repairs
Hinder Plant Production

Oil leaks from bearings and is thrown on armatures. It soaks through windings and causes short-circuits that result in "burn-outs." You lose production time until the motor is repaired or replaced.

Not so with NON-FLUID OIL. Motor troubles go down and production goes up. Drip-less, waste-less NON-FLUID OIL stays in bearings and off windings. Motors are kept in constant service at lowest maintenance cost. Cuts lubricant cost too — outlasts oil 3 to 5 times.

Used successfully in leading iron and steel mills. Send for instructive bulletin.

•

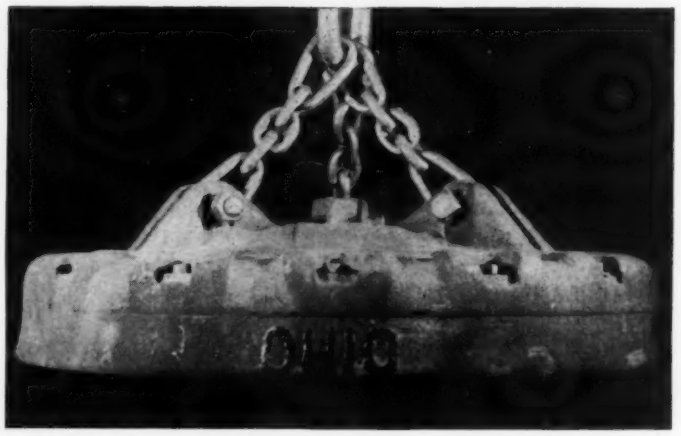
New York & New Jersey Lubricant Co.
Main Office: 292 Madison Ave., New York, N. Y.
WAREHOUSES:
Chicago, Ill. — Atlanta, Ga.
St. Louis, Mo. — Detroit, Mich.
Providence, R. I. — Greenville, S. C.

TRADE MARK REGISTERED
NON-FLUID OIL
IN U.S. PAT. OFFICE & FOREIGN COUNTRIES

MODERN STEEL MILL LUBRICANT

Better Lubrication at Less Cost per Month

A 17 Year Old Ohio Magnet



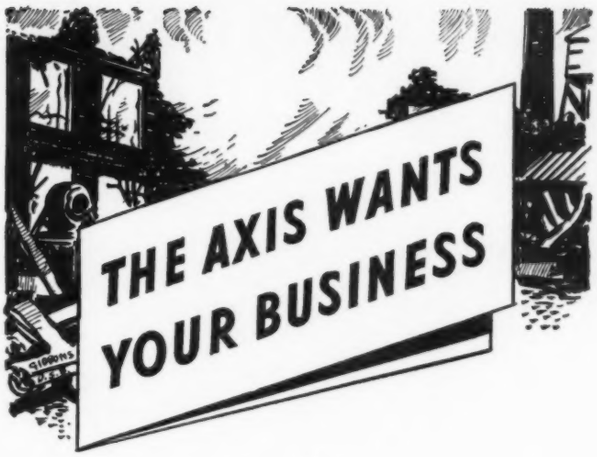
In continuous service without major repair.

Outer ring worn down 4 inches but not cracked. Water finally got in and grounded coil.

Ohio Magnets give long service at low maintenance cost.

OHIO reliable MAGNETS

The OHIO Electric Mfg. Company
5907 Maurice Avenue
Cleveland - - Ohio



THIS is more than a war of mechanical monsters clashing in the night . . . more than a war of production.

It is a war for markets—*your* markets! The Axis wants your business—wants to destroy it for once and all.

With so much at stake, there is no doubt you will want to do everything you can to meet this Axis threat. Two ways are open: Speed production and BUY BONDS. The only answer to enemy tanks and planes is *more* American tanks and planes—and your regular, month-by-month purchases of Defense Bonds will help supply them. Buy now *and keep buying.*

HOW THE PAY-ROLL SAVINGS PLAN HELPS

When you install the Pay-Roll Savings Plan (approved by organized labor), you not only perform a service for your country but for your *employees.* Simple to install, the Plan provides for regular purchases of Defense Bonds through voluntary pay roll allotments.

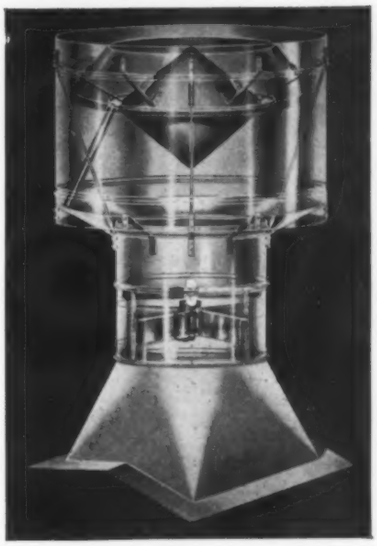
Write for details *today!* Treasury Department, Section R, 709 Twelfth Street, NW., Washington, D. C.

U. S. SAVINGS

Bonds ★ Stamps

★★★★★★★★★★★

BURT
VENTILATORS



FREE-FLOW FAN TYPE

Add to Safety
Step Up Morale

Provide your workers clean, fresh air and you will find them more alert, vigorous and happy. Nothing like Burt ventilation to improve your safety records and increase production. Particularly designed for moving a large volume of hot fume-laden air from a definite locality is the Burt Free-Flow Fan type, illustrated above. Its capacity is several times that of gravity ventilators of the same size. Gives positive, uniform, dependable operation in all situations, at all seasons, no matter what the weather or wind direction.

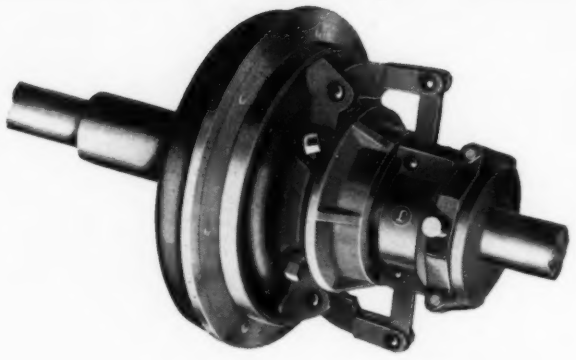
Burt makes three types specially adapted for steel mill installations, — Free-Flow Fan, Free-Flow Gravity and the Monovent Continuous Ridge Ventilator. All are scientifically designed for high efficiency and sturdily built to give long dependable service.

Send for data sheets and job references. Do not hesitate to call on Burt Engineers for assistance in estimating and laying out plans.

THE BURT MFG. CO.
ROOF VENTILATORS • OIL FILTERS
EXHAUST HEADS
950 SOUTH HIGH STREET AKRON, OHIO

SEND FOR CATALOGS
•
Burt Engineers are glad to help on plans

JONES-LEMLEY FRICTION CLUTCHES



JONES-LEMLEY friction clutches are built for a broad range of shaft sizes and ratings in both enclosed and open types for sleeve and coupling work. In addition they are available in a line of Jones-Lemley friction clutch pulleys. This clutch modification is also used for gears, V-belt sheaves, sprocket wheels, etc. Sizes, ratings, dimensions, prices and other data are contained in Bulletin No. 60. Your request will bring a copy.

W. A. JONES FOUNDRY & MACHINE CO., 4431 Roosevelt Rd., Chicago, Illinois

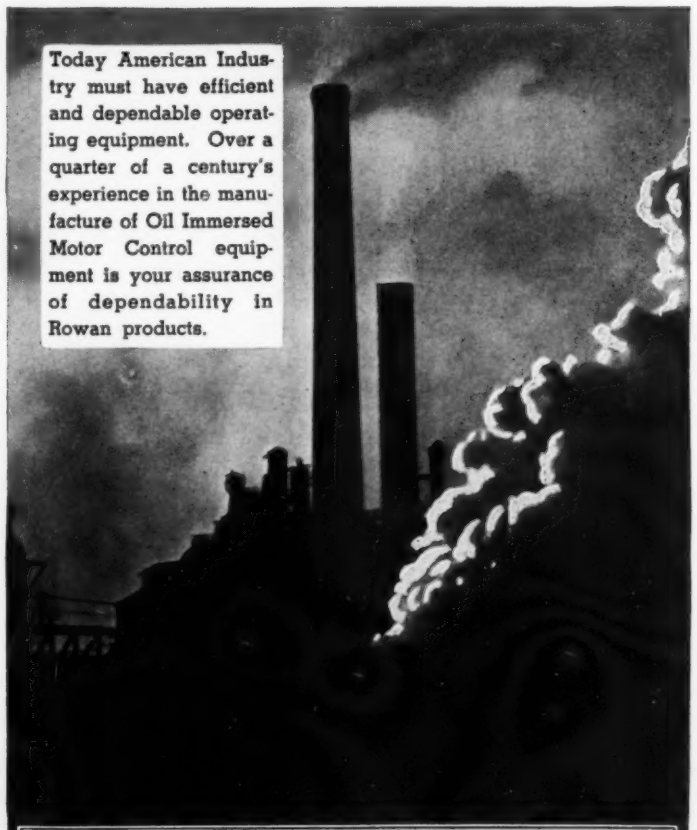
Jones

HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS • PULLEYS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES

ROWAN
Oil Immersed
MOTOR CONTROL

BY
USERS
EVERYWHERE

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.



Today American Industry must have efficient and dependable operating equipment. Over a quarter of a century's experience in the manufacture of Oil Immersed Motor Control equipment is your assurance of dependability in Rowan products.

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

INDEX TO ADVERTISERS

A

Aetna-Standard Engineering Company 1
Air Reduction Sales Company CS-48
Alliance Machine Company CS-50
Aluminum Company of America 37
American Hammered Piston Ring Division of Koppers Company 67

B

Baker-Raulang Company 14
Bartlett-Hayward Division of Koppers Company 67
Bedford Foundry and Machine Company CS-45
Birdsboro Steel Foundry and Machine Company 72
Bonnot Company 10
Broden Construction Company 11
Burt Manufacturing Company 75
Bussmann Manufacturing Company 52-53

C

Clark Controller Company CS-46, 47
Cleveland Crane and Engineering Company CS-31
Cleveland Worm and Gear Company CS-51
Crouse-Hinds Company 62
M. E. Cunningham Company 66
Cutler-Hammer, Inc. ..... Cover 2

D

De Laval Steam Turbine Company 65
John C. Dolph Company 24

E

Electric Controller and Manufacturing Company 5-CS-39
Electric Service Supplies Company CS-44
Engineering and Construction Division of Koppers Company 67

F

Farrel-Birmingham Company, Inc. 63
Farval Corporation CS-52
Flinn and Dreffein Company 11

G

Gas and Coke Division of Koppers Company 67
Gatke Corporation 65
General Electric Company ..... CS-43, 8-9, Cover 4

H

Hagan Corporation 68
Hallden Machine Company 11
Harnischfeger Corporation CS-32
Hays Corporation 60
Heppenstall Company 22
Hyatt Bearings Division, General Motors Corporation CS-40
Hydropress, Inc. 6

I

I-T-E Circuit Breaker Company ..... Cover 3

J

W. A. Jones Foundry and Machine Company 76

K

Koppers Coal Company 67
Koppers Company 67
Koppers-Rheolaveur Company 67

L

Leeds and Northrup Company 7
Lewis Foundry and Machine Division, Blaw-Knox Company 18
Lincoln Engineering Company 70
Linde Air Products Company 57
Link-Belt Company 12
Lintern Corporation CS-41

M

Mackintosh-Hemphill Company 55
Maryland Drydock Company 67
Mathews Conveyor Company 2
James H. Matthews and Company 65
McKay Machine Company 11
Mesta Machine Company ..... Cover 1
Morgan Construction Company 69
Morgan Engineering Company CS-34

N

National Carbon Company, Inc., Carbon Sales Division 16
National Roll and Foundry Company 45
New York and New Jersey Lubricant Company 74
Norma-Hoffmann Bearings Corporation CS-30
North American Manufacturing Company 17

O

Ohio Electric Manufacturing Company 74
Ohio Steel Foundry Company 23
Okonite Company 78

P

Pennsylvania Transformer Company 71
Pittsburgh Rolls Division, Blaw-Knox Company 13
Poole Foundry and Machine Company 56
Post-Glover Electric Company CS-49
Pyle-National Company 4

R

Rockbestos Products Corporation 41
Rowan Controller Company 76
Fred J. Ryan Company 66

S

Salem Engineering Company 19
SKF Industries, Inc. CS-33
Swindell-Dressler Corporation 26

T

Tar and Chemical Division of Koppers Company 67
Timken Roller Bearing Company CS-42
Tool Steel Gear and Pinion Company CS-37
Truflo Fan Company CS-38

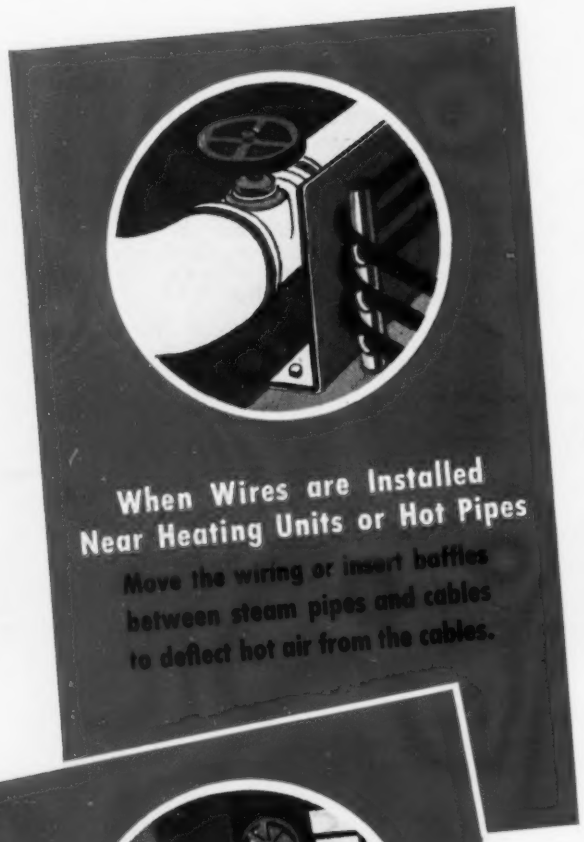
U

Union Carbide and Carbon Corporation 16
United Engineering and Foundry Corporation 20-21

W

Wagner Electric Corporation 73-25, CS-35
Wean Engineering Company, Inc. 11
Wean Engineering Company of Canada, Ltd. 11
Wellman Smith Owens Engineering Corporation, Ltd. 11
Western Gas Division of Koppers Company 67
Westinghouse Electric and Manufacturing Company CS-36
White Tar Company of New Jersey, Inc. 67
Lee Wilson Engineering Company 15
Wood Preserving Corporation 67

Prolong the Life of Wiring Circuits in HOT LOCATIONS



When Wires are Installed Near Heating Units or Hot Pipes

Move the wiring or insert baffles between steam pipes and cables to deflect hot air from the cables.

When Wires are Installed in Hot Rooms

Provide circulation by the use of fans to blow hot air away. Such precautions are less necessary if you are already using Okolite heat-resisting rubber, Okoglass or Okobestos cables which are designed for long life under these conditions.

Where Only Mildly High Temperatures Exist

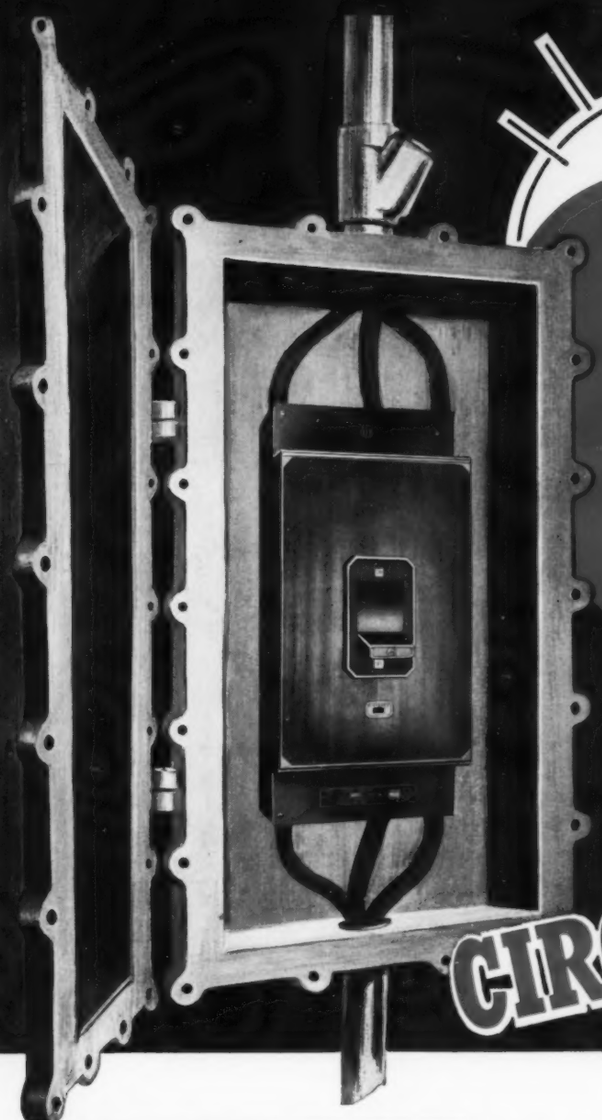
Cut air vents in the ceiling or partition providing adequate circulation by means of natural convection.

In this war, we must save materials wherever possible. One way to do this, is to make your present wiring circuits last longer than ever before, because rubber, synthetics, copper and steel are needed for our war effort.

Write for free booklet with 19 Helpful illustrated ideas on "How to Get Longer Service from Rubber Insulated Wires & Cables"

THE OKONITE COMPANY
Passaic, New Jersey
Offices in Principal Cities

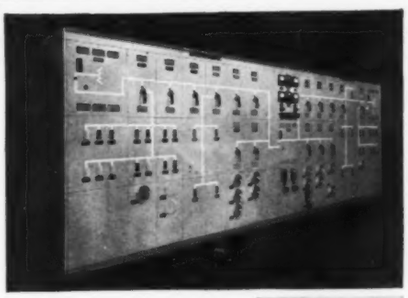
OKONITE
Insulated Wires and Cables



IN EXPLOSIVE ATMOSPHERES

in hundreds of process plants

CIRCUIT BREAKERS are by I-T-E



These are readily identified as the work of I-T-E

Steel-enclosed switchboards and individually mounted circuit breakers have carried the I-T-E symbol into the plants of industry. These units represent the work for which I-T-E is known. But, as the text at the right indicates, the field of I-T-E usefulness is even broader.

THOUSANDS OF WORKERS in plants over the country perform their tasks unaware that I-T-E is helping them.

Take, for example, the many instances in industry in which ignitible vapors or explosive dust may gather. With that condition, circuit breakers must be enclosed in heavy metal cases, built to withstand great forces of internal explosion. In large, explosion-proof units, as many as fifty stout bolts hold the cover of the housing in place.

The identity of the circuit breaker is lost to almost everyone in the plant except the few men who must know about these things. Yet the business of supplying circuit breakers to be enclosed in weatherproof, watertight, dusttight, vaportight and explosion-proof cases has been a large and steadily growing enterprise with I-T-E for quite a few years.

The field of usefulness in giving protection—to electrical circuits, to connected equipment and to operators—is broad, and for over fifty years the activity of I-T-E in this field has been expanding. More new developments by I-T-E will come.

I-T-E

AIR SWITCHGEAR

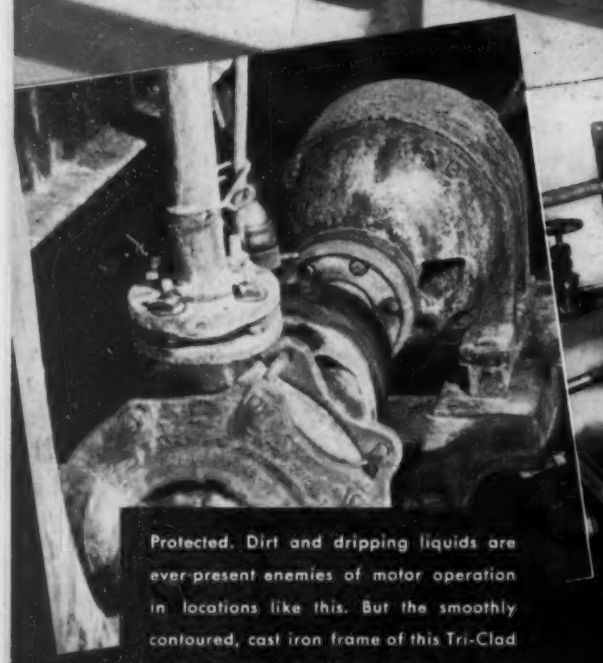
IMMERSED IN AIR • ENCASED IN STEEL

Representatives in Principal Cities

CIRCUIT BREAKER CO., PHILADELPHIA, PA.

MORE "STAYING POWER" ON PUMPING JOBS

Triple-shift operation is an old story to this Tri-Clad motor driving a coolant pump. Tri-Clad motors are now available up to 100 hp in standard, open construction, and in a wide range of other types and ratings.



Protected. Dirt and dripping liquids are ever-present enemies of motor operation in locations like this. But the smoothly contoured, cast iron frame of this Tri-Clad motor guards it against damage.

Long Lasting. This Tri-Clad motor is an excellent running mate for the chlorinating pump it drives. Its extra-protection features—cast iron frame, windings of Formex wire, improved bearings—are assurance of long life on important jobs.

The extra protection of TRI/CLAD MOTORS helps keep pumps delivering

NOW—before you buy motors—is the time to solve your pump-motor problems. Wherever continuous pumping is essential to your production—wherever pumps must operate under adverse conditions—your motors must be secure against 1) physical damage, 2) electrical breakdown, 3) operating wear and tear.

Here's where the *extra*-protection features of Tri-Clad motors will help you get the triple-shift operation you need. Their cast-iron frames and end shields exclude falling objects and dripping liquids; their windings, of Formex wire, are resistant to oil, moisture, and heat shock; their improved bearings, completely sealed in cast iron, are protected against the entry of dust and dirt. All these features add up to *extra staying power* on jobs where 24-hour production is essential.

How to Get Motors Quicker

USE STANDARD MOTORS. Wherever possible, select standard, open, sleeve-bearing motors. Building fewer "specials" means faster and greater production of motors for war work.

PLACE ORDERS EARLY. Order the motors when you order, or plan for, the equipment they are to drive.

SEND PROPER PRIORITY. Be sure correct priority papers accompany your order and that the priority rating reflects the urgency of the motor's use in the war.

CHECK G.E. for warehouse stocks. A supply of many standard motors are kept on hand to meet urgent war needs. Perhaps the motor you want, or can use with a few simple changes, is available for immediate shipment.

General Electric, Schenectady, N. Y.

General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.

BUILT FOR PROTECTION FIRST..TO LAST

GENERAL ELECTRIC

750-107-8030